Environmental and fisheries influences on fish stock recruitment in the Baltic Sea
(FAIR CT 98 3959)

STOck **RE**cruitment in the Baltic

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Final Consolidated Report
Part II
Tables & Figures

This volume presents Tables and Figures complementing the Final Consolidated Report of the project “Environmental and fisheries influences on fish stock recruitment in the Baltic Sea STORE” (FAIR CT 98 3959).

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FAIR CT 98 3959

Environmental and fisheries influence on fish stock recruitment in the Baltic Sea (STORE)

Final Consolidated Report

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Table 1.1.1. Estimated model parameters ± S.E. and derived characteristics ± S.E. for critical oxygen saturation and salinity.

Parameter	Baltic cod	Herring	Sprat
A	99.0±60.4	290.4±149.4	3357.8±1108.2
α	0.1722±0.1072	0.1368±0.0921	0.1384±0.1481
β	0.8845±0.1648	1.2570±0.8370	0.9639±0.7248
p_{50}	14.8±7.2	16.5±10.0	11.2±8.0
s_{50}	12.39±1.27	9.31±1.52	8.11±0.95
σ	0.8885±0.0901	1.7632±0.1772	1.7684±0.1812
γ	0.5677±0.2617	0.0419±0.0230	0.0012±0.0002
p_c	7.14±4.39	3.10±6.94	2.51±8.22
s_c	10.91±1.01	7.85±0.47	6.86±0.70

Tab. 1.1.2. Sprat number (million) per age group and rectangle/Sub-division in May/June 1999.

Sub-div.	ICES Rectangle	Age groups 1	2	3	4	5	6	7	8+	3+	Sum
24	**38G2**	1.1	166.3	100.0	173.0	85.7	1.1	1.1	1.6	362.4	529.7
24	**38G3**	3.1	357.5	240.9	606.2	326.4	6.2	4.7	9.3	1193.8	1554.4
24	**38G4**	27.2	345.5	180.9	348.7	175.5	3.3	2.2	5.4	716.0	1088.7
24	**39G2**	0.3	49.5	30.5	62.0	32.2	0.4	0.4	0.6	126.1	175.9
24	**39G3**	1.3	332.6	211.0	506.2	273.8	4.0	2.7	5.3	1003.0	1336.9
24	**39G4**	3.0	212.2	116.4	180.6	91.5	0.6	0.6	1.2	391.0	606.2
24	**Total**	**36.0**	**1463.5**	**879.7**	**1876.8**	**985.1**	**15.6**	**11.5**	**23.5**	**3792.3**	**5291.8**
25	**37G5**	3.2	945.7	1584.6	639.0	22.4	0.0	0.0	0.0	2245.9	3194.8
25	**38G5**	0.7	210.5	352.8	142.2	5.0	0.0	0.0	0.0	500.0	711.2
25	**38G6**	0.9	614.0	810.1	293.6	8.6	0.0	0.0	0.0	1112.4	1727.3
25	**39G4**	0.0	564.3	475.0	147.6	3.6	0.0	0.0	0.0	626.2	1190.5
25	**39G5**	0.0	1587.4	1511.5	506.2	10.8	0.0	0.0	0.0	2028.6	3616.1
25	**39G6**	0.0	1196.7	1274.6	403.7	8.7	0.0	0.0	0.0	1687.0	2883.7
25	**39G7**	0.0	2471.1	1436.1	396.8	8.6	0.0	0.0	0.0	1841.5	4312.6
25	**40G4**	0.0	291.6	288.9	90.0	1.3	0.0	0.0	0.0	380.3	671.9
25	**40G5**	0.0	2747.8	1365.0	324.6	4.4	0.0	0.0	0.0	1694.0	4441.8
25	**40G6**	0.0	2811.8	1707.0	452.9	10.0	0.0	0.0	0.0	2169.8	4981.6
25	**40G7**	0.0	2096.5	678.4	133.9	2.9	0.0	0.0	0.0	815.3	2911.8
25	**41G6**	0.0	2700.7	2302.7	670.9	11.4	0.0	0.0	0.0	2985.0	5685.8
25	**41G7**	0.0	2869.7	1289.3	317.9	4.5	0.0	0.0	0.0	1611.7	4481.4
25	**Total**	**4.8**	**21107.9**	**15076.1**	**4519.4**	**102.2**	**0.0**	**0.0**	**0.0**	**19697.7**	**40810.4**
26	**39G8**	128.1	2940.5	1757.2	292.0	0.0	0.0	0.0	0.0	2049.2	5117.8
26	**40G8**	5.9	3380.9	2171.3	342.2	0.0	0.0	0.0	0.0	2513.6	5900.4
26	**41G8**	3.1	1653.6	1172.9	235.8	0.0	0.0	0.0	0.0	1408.6	3065.3
26	**Total**	**137.0**	**7975.1**	**5101.3**	**870.0**	**0.0**	**0.0**	**0.0**	**0.0**	**5971.4**	**14083.5**
27	**42G7**	0.0	2104.9	1884.2	1098.7	46.2	0.0	0.0	0.0	3029.1	5134.0
28	**42G8**	0.0	567.9	718.1	424.6	15.5	0.0	0.0	0.0	1158.2	1726.1
24-28	**Total**	**177.8**	**33219.3**	**23659.4**	**8789.5**	**1149.1**	**15.6**	**11.5**	**23.5**	**33648.6**	**67045.8**

Tab. 1.1.3. Sprat mean weight (g) per age group and rectangle in May/June 1999.

Sub-div.	ICES Rectangle	Age groups 1	2	3	4	5	6	7	8+
24	38G2	8.1	11.3	12.3	14.0	14.3	19.7	19.7	19.7
24	38G3	6.3	12.3	13.7	14.8	14.7	20.6	19.7	20.2
24	38G4	5.9	11.0	12.6	14.3	14.6	20.5	19.7	20.1
24	39G2	8.1	11.7	12.9	14.4	14.5	20.3	19.7	20.1
24	39G3	8.1	12.1	13.4	14.7	14.6	20.8	19.7	20.4
24	39G4	7.1	11.0	11.7	13.3	13.8	20.5	19.7	20.1
25	37G5		9.7	12.2	13.0	13.3			
25	38G5		9.7	12.2	13.0	13.3			
25	38G6		8.7	11.7	12.7	13.3			
25	39G4		7.2	10.9	12.1	13.3			
25	39G5		7.2	11.2	12.5	13.3			
25	39G6		7.7	11.1	12.3	13.3			
25	39G7		5.8	10.6	11.9	13.3			
25	40G4		7.9	10.8	12.0	13.3			
25	40G5		5.7	10.1	11.4	13.3			
25	40G6		5.7	10.7	12.5	13.3			
25	40G7		5.0	9.8	11.5	13.3			
25	41G6		6.9	10.6	11.7	13.3			
25	41G7		5.6	10.3	12.0	13.3			
26	39G8	5.0	6.6	8.2	9.3				
26	40G8	5.0	6.8	8.1	9.6				
26	41G8	5.0	6.9	8.3	9.6				
27	42G7		7.3	9.4	10.1	14.1			
28	42G8		7.8	9.4	10.1	13.1			

Tab. 1.1.4. Sprat total biomass (t) per age group and rectangle/Sub-division in May/June 1999.

Sub-div.	ICES Rectangle	Age groups 1	2	3	4	5	6	7	8+	3+	Sum
24	38G2	8.6	1878.9	1229.8	2421.8	1225.5	20.8	20.8	31.3	4950.1	6837.6
24	38G3	19.6	4397.5	3300.8	8972.2	4798.5	128.1	91.9	188.4	17479.9	21897.0
24	38G4	160.7	3800.1	2279.4	4986.9	2561.7	67.0	42.9	109.5	10047.4	14008.2
24	39G2	2.1	578.8	391.6	889.8	465.7	8.9	6.9	12.3	1775.3	2356.2
24	39G3	10.8	4024.0	2827.7	7441.0	3997.4	83.3	52.6	109.0	14511.1	18545.9
24	39G4	21.5	2333.8	1361.7	2402.6	1263.2	12.4	11.9	24.4	5076.2	7431.5
24	**Total**	**223.4**	**17013.2**	**11391.1**	**27114.2**	**14312.0**	**320.6**	**227.1**	**474.9**	**53839.9**	**71076.5**
25	37G5	0.0	9172.9	19332.3	8306.4	297.4	0.0	0.0	0.0	27936.1	37109.0
25	38G5	0.0	2042.0	4303.6	1849.1	66.2	0.0	0.0	0.0	6218.9	8260.9
25	38G6	0.0	5342.2	9437.6	3714.5	114.9	0.0	0.0	0.0	13267.0	18609.2
25	39G4	0.0	4062.8	5177.4	1786.2	47.5	0.0	0.0	0.0	7011.0	11073.8
25	39G5	0.0	11429.6	16928.9	6328.1	144.3	0.0	0.0	0.0	23401.3	34830.9
25	39G6	0.0	9214.9	14148.1	4965.8	115.1	0.0	0.0	0.0	19228.9	28443.8
25	39G7	0.0	14332.6	15222.8	4721.5	114.7	0.0	0.0	0.0	20059.0	34391.6
25	40G4	0.0	2303.6	3120.2	1080.4	17.9	0.0	0.0	0.0	4218.5	6522.1
25	40G5	0.0	15662.4	13786.5	3700.2	59.1	0.0	0.0	0.0	17545.8	33208.2
25	40G6	0.0	16027.3	18264.8	5660.9	132.4	0.0	0.0	0.0	24058.1	40085.5
25	40G7	0.0	10482.4	6648.8	1540.3	38.7	0.0	0.0	0.0	8227.8	18710.3
25	41G6	0.0	18635.1	24409.0	7849.8	151.2	0.0	0.0	0.0	32410.0	51045.1
25	41G7	0.0	16070.3	13280.3	3814.3	59.5	0.0	0.0	0.0	17154.2	33224.5
25	**Total**	**0.0**	**134778.1**	**164060.2**	**55317.5**	**1359.0**	**0.0**	**0.0**	**0.0**	**220736.6**	**355514.7**
26	39G8	640.4	19407.6	14408.7	2715.6	0.0	0.0	0.0	0.0	17124.3	37172.3
26	40G8	29.5	22990.3	17587.9	3285.3	0.0	0.0	0.0	0.0	20873.2	43893.0
26	41G8	15.3	11410.0	9734.7	2263.6	0.0	0.0	0.0	0.0	11998.3	23423.7
26	**Total**	**685.2**	**53807.9**	**41731.2**	**8264.6**	**0.0**	**0.0**	**0.0**	**0.0**	**49995.8**	**104488.9**
27	42G7	0.0	15366.1	17711.4	11096.7	651.5	0.0	0.0	0.0	29459.5	44825.7
28	42G8	0.0	4429.5	6749.7	4288.6	203.5	0.0	0.0	0.0	11241.8	15671.3
24-28	**Total**	**908.5**	**225394.8**	**241643.5**	**106081.6**	**16526.0**	**320.6**	**227.1**	**474.9**	**365273.7**	**591577.1**

Table 1.1.5. Estimated numbers (millions) of sprat in May/June 2001.

Sub-division	Rectangle	Age groups 1	2	3	4	5	6	7	8+	Total
24	**38G2**	1.9	23.5	14.6	86.2	38.5	8.4	0.3		173.4
24	**38G3**	5.6	104.8	62.9	356.7	159.5	37.3	2.3		729.1
24	**38G4**	22.2	490.2	440.7	1382.5	597.1	80.4	2.6		3015.5
24	**39G2**	2.0	24.9	15.5	91.6	40.9	8.9	0.4		184.2
24	**39G3**	2.7	24.7	16.0	98.2	43.7	8.9	0.2		194.3
24	**39G4**	29.2	55.5	35.3	118.3	51.3	7.0	0.3		296.8
24	**Total**	**63.5**	**723.5**	**584.9**	**2133.6**	**930.9**	**150.9**	**6.0**		**4593.2**
25	**37G5**	1.1	389.5	536.7	1445.1	326.4	97.7	13.9		2810.3
25	**38G5**	0.1	22.0	30.5	85.6	19.3	5.9	0.7		163.9
25	**38G6**	0.7	189.4	258.9	641.4	146.1	42.4	7.9		1286.8
25	**39G4**	0.4	37.8	52.3	118.6	23.3	6.2	0.4		239.0
25	**39G5**	2.2	150.7	188.5	424.2	86.8	24.8	1.6		878.9
25	**39G6**	7.1	215.5	272.5	530.1	97.2	22.9	1.5		1146.8
25	**39G7**	478.2	1260.8	825.3	980.2	117.9	16.5	0.2		3678.9
25	**40G4**	0.8	81.5	112.7	255.6	50.1	13.4	0.9		515.0
25	**40G5**	16.0	580.5	731.9	1597.9	325.9	89.4	5.3		3346.8
25	**40G6**	16.1	923.8	922.0	1516.2	245.7	49.7	1.8		3675.4
25	**40G7**	26.8	852.5	749.3	1144.9	171.8	29.3	0.8		2975.4
25	**41G6**	102.4	1998.8	1340.1	1586.4	194.3	27.9	0.3		5250.1
25	**41G7**	142.2	1298.0	847.7	1150.4	155.2	21.4	0.4		3615.2
25	**Total**	**793.9**	**8000.8**	**6868.3**	**11476.6**	**1959.8**	**447.5**	**35.5**		**29582.4**
26	**39G8**	2278.2	1337.6	854.4	1626.9	157.2	0.0	0.0		6254.3
26	**40G8**	425.9	1454.6	1073.5	2252.4	232.6	0.0	0.0		5439.0
26	**41G8**	281.3	822.2	675.2	1462.9	151.2	0.0	0.0		3392.8
26	**Total**	**2985.4**	**3614.4**	**2603.1**	**5342.3**	**541.0**	**0.0**	**0.0**		**15086.1**
27	**42G7**	27.3	1418.4	615.3	1233.6	736.3	50.6	0.0		4081.5
28	**42G8**	511.9	668.3	422.8	856.7	550.8	41.5	0.0		3052.0
24-28	**Total**	**4381.9**	**14425.3**	**11094.4**	**21042.8**	**4718.8**	**690.6**	**41.5**		**56395.2**

Table1.1.6. Sprat mean weight (g) per age group in May/June 2001.

Sub-division	Rectangle	Age groups 1	2	3	4	5	6	7	8+	Total
24	**38G2**	8.70	14.80	13.20	16.30	16.30	18.00	22.90		15.90
24	**38G3**	10.30	14.60	13.10	16.30	16.60	18.40	22.90		15.90
24	**38G4**	10.50	13.40	12.90	15.00	15.30	17.30	22.90		14.50
24	**39G2**	8.70	14.80	13.20	16.30	16.30	18.00	22.90		15.90
24	**39G3**	7.80	15.10	13.30	16.20	16.10	17.60	22.90		15.80
24	**39G4**	7.10	12.40	12.70	14.90	15.30	17.50	22.90		13.60
25	**37G5**	8.10	12.50	12.70	13.50	14.50	15.10	21.90		13.40
25	**38G5**	8.40	12.60	12.80	13.60	14.50	15.10	21.40		13.50
25	**38G6**	7.70	12.20	12.40	13.40	14.60	15.10	22.50		13.30
25	**39G4**	7.00	11.70	12.00	12.90	13.70	14.60	19.80		12.70
25	**39G5**	7.00	11.50	12.00	13.10	13.90	14.90	17.90		12.70
25	**39G6**	6.10	11.00	11.50	12.50	13.30	14.30	18.50		12.10
25	**39G7**	5.30	9.10	10.30	10.80	11.40	12.10	15.90		9.40
25	**40G4**	7.00	11.70	12.00	12.90	13.70	14.60	19.80		12.70
25	**40G5**	6.10	11.40	11.90	13.00	13.80	14.80	15.90		12.60
25	**40G6**	7.80	10.10	11.10	12.00	12.70	13.60	15.90		11.30
25	**40G7**	7.10	9.80	10.80	11.70	12.30	13.10	15.90		10.90
25	**41G6**	6.90	9.20	10.30	10.90	11.40	12.10	15.90		10.00
25	**41G7**	6.10	9.20	10.50	11.30	12.00	12.90	15.90		10.20
26	**39G8**	4.50	7.90	9.30	10.10	10.30				7.50
26	**40G8**	4.70	8.20	9.30	10.20	10.20				9.00
26	**41G8**	4.50	8.20	9.50	10.20	10.30				9.10
27	**42G7**	6.90	8.70	10.20	10.40	10.70	11.20			9.80
28	**42G8**	4.70	8.90	10.30	10.50	10.80	11.20			9.20

Table 1.1.7. Sprat total biomass (t) per age group in May/June 2001.

Sub-division	Rectangle	Age groups 1	2	3	4	5	6	7	8+	Total
24	**38G2**	16.1	347.4	192.7	1405.7	626.8	151.2	7.9		2756.3
24	**38G3**	57.8	1529.7	824.0	5814.6	2647.6	686.4	52.5		11592.7
24	**38G4**	233.3	6568.1	5684.5	20737.0	9134.9	1390.2	59.4		43724.9
24	**39G2**	17.1	369.1	204.7	1493.6	666.0	160.6	8.4		2928.6
24	**39G3**	20.7	372.9	212.2	1591.5	703.3	156.3	3.6		3069.3
24	**39G4**	207.0	687.8	447.7	1763.0	785.2	122.5	5.9		4036.2
24	**Total**	**552.0**	**9875.0**	**7565.8**	**32805.4**	**14563.8**	**2667.2**	**137.7**		**68166.9**
25	**37G5**	9.1	4868.9	6815.6	19508.2	4732.2	1475.9	303.8		37658.3
25	**38G5**	0.4	277.4	390.0	1163.8	279.1	88.4	15.2		2212.9
25	**38G6**	5.6	2310.8	3209.8	8595.2	2132.8	639.8	177.5		17114.0
25	**39G4**	2.6	442.3	627.6	1529.6	318.7	90.8	8.7		3034.9
25	**39G5**	15.2	1733.4	2262.4	5557.6	1206.8	369.4	27.8		11161.4
25	**39G6**	43.1	2370.5	3133.2	6626.7	1293.1	327.9	27.3		13876.3
25	**39G7**	2534.2	11473.3	8500.1	10585.8	1343.5	200.1	2.7		34582.0
25	**40G4**	5.7	953.2	1352.7	3296.6	686.8	195.7	18.7		6540.9
25	**40G5**	97.4	6617.5	8709.4	20773.2	4496.7	1323.1	83.4		42169.3
25	**40G6**	125.2	9330.2	10234.6	18194.8	3120.7	676.5	29.2		41532.0
25	**40G7**	190.5	8354.9	8092.5	13395.3	2112.7	384.1	12.2		32432.1
25	**41G6**	706.5	18388.7	13803.0	17291.5	2215.5	337.1	4.1		52500.9
25	**41G7**	867.3	11941.2	8901.1	12999.6	1862.1	275.6	5.8		36874.7
25	**Total**	**4602.8**	**79062.3**	**76032.0**	**139517.9**	**25800.7**	**6384.4**	**716.4**		**332116.5**
26	**39G8**	10252.1	10566.9	7945.9	16432.0	1618.8	0.0	0.0		46907.4
26	**40G8**	2001.6	11927.8	9983.9	22974.3	2372.7	0.0	0.0		48951.2
26	**41G8**	1266.0	6741.8	6414.4	14922.0	1557.0	0.0	0.0		30874.6
26	**Total**	**13519.7**	**29236.5**	**24344.2**	**54328.3**	**5548.5**	**0.0**	**0.0**		**126977.2**
27	**42G7**	188.3	12339.6	6275.8	12829.6	7878.8	567.1	0.0		39998.6
28	**42G8**	2405.7	5947.6	4355.2	8995.2	5948.8	465.1	0.0		28078.3
24-28	**Total**	**21268.5**	**136461.0**	**118573.0**	**248476.4**	**59740.6**	**10083.8**	**854.1**		**595337.5**

Tab. 1.1.8. Herring number (million) per age group and retangle/Sub-division in May/June 1999.

Sub-div.	ICES Rectangle	Age groups 1	2	3	4	5	6	7	8+	3+	Sum
24	**38G2**	201.9	282.1	28.0	43.5	27.3	9.3	22.4	7.5	137.9	622.0
24	**38G3**	118.9	129.5	23.0	29.1	18.1	3.6	1.3	0.3	75.5	323.8
24	**38G4**	17.9	96.9	23.3	20.4	17.0	3.2	1.4	0.2	65.5	180.2
24	**39G2**	18.7	31.1	4.9	5.7	3.9	0.9	1.2	0.4	17.0	66.7
24	**39G3**	4.0	8.1	1.7	1.7	1.3	0.2	0.0	0.0	4.9	17.1
24	**39G4**	13.8	27.0	5.4	7.9	4.6	1.8	1.2	0.2	21.1	61.8
24	**Total**	**375.1**	**574.7**	**86.2**	**108.3**	**72.3**	**19.0**	**27.5**	**8.6**	**321.8**	**1271.5**
25	**37G5**	9.9	64.0	32.2	101.6	127.2	40.1	26.4	11.6	339.1	413.0
25	**38G5**	2.2	14.3	7.2	22.6	28.3	8.9	5.9	2.6	75.5	91.9
25	**38G6**	5.2	24.8	9.2	31.1	37.9	11.2	9.0	3.5	101.8	131.8
25	**39G4**	0.8	2.1	0.3	1.3	1.3	0.2	0.1	0.0	3.2	6.1
25	**39G5**	0.7	7.5	3.4	11.7	13.3	2.8	1.9	0.8	33.9	42.1
25	**39G6**	4.5	17.9	5.0	18.3	21.7	5.9	5.8	2.0	58.9	81.3
25	**39G7**	0.1	0.9	0.4	1.2	1.4	0.3	0.4	0.1	3.8	4.7
25	**40G4**	1.7	4.6	1.3	4.4	4.9	1.0	0.6	0.2	12.3	18.7
25	**40G5**	1.1	5.8	2.1	7.8	9.3	2.4	1.7	0.7	24.0	30.9
25	**40G6**	36.5	54.4	3.3	19.5	17.5	1.3	0.7	0.3	42.5	133.5
25	**40G7**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	**41G6**	0.1	0.6	0.3	0.9	0.8	0.1	0.0	0.0	2.1	2.8
25	**41G7**	0.1	2.5	0.6	2.0	1.7	0.2	0.1	0.0	4.6	7.2
25	**Total**	**63.0**	**199.4**	**65.3**	**222.4**	**265.3**	**74.3**	**52.6**	**21.8**	**701.7**	**964.1**
26	**39G8**	0.0	0.8	0.4	1.7	2.0	0.6	0.4	0.2	5.4	6.1
26	**40G8**	0.0	1.5	1.1	2.3	2.8	0.3	0.2	0.1	6.7	8.3
26	**41G8**	0.0	1.9	0.2	2.2	2.3	0.3	0.1	0.1	5.2	7.1
26	**Total**	**0.0**	**4.2**	**1.7**	**6.2**	**7.1**	**1.2**	**0.6**	**0.4**	**17.3**	**21.5**
27	**42G7**	0.0	8.2	4.9	18.6	66.6	18.2	5.5	1.0	114.8	123.0
28	**42G8**	0.0	3.4	0.8	2.6	4.5	0.7	0.2	0.2	8.9	12.3
24-28	**Total**	**438.1**	**789.9**	**158.9**	**358.0**	**415.7**	**113.5**	**86.4**	**31.9**	**1164.5**	**2392.5**

Tab. 1.1.9. Herring mean weight (g) per age group and rectangle in May/June 1999.

Sub-div.	ICES Rectangle	Age groups 1	2	3	4	5	6	7	8+
24	**38G2**	26.7	36.3	50.2	43.4	56.6	76.2	112.7	95.8
24	**38G3**	22.5	37.1	53.0	51.3	60.0	75.3	92.7	175.0
24	**38G4**	26.7	43.1	52.5	58.1	58.4	75.8	95.6	94.8
24	**39G2**	25.2	38.2	51.1	48.6	56.8	74.3	99.8	102.9
24	**39G3**	23.6	40.1	52.0	53.7	57.0	72.3	86.8	110.0
24	**39G4**	22.5	39.9	53.3	60.0	63.1	74.3	96.1	98.1
25	**37G5**	18.2	34.0	43.0	42.7	47.8	63.0	71.5	73.9
25	**38G5**	18.2	34.0	43.0	42.7	47.8	63.0	71.5	73.9
25	**38G6**	18.4	32.1	42.3	41.2	46.5	66.1	75.7	77.2
25	**39G4**	16.6	22.8	40.9	39.2	40.2	54.9	54.9	56.7
25	**39G5**	18.8	34.3	42.0	41.6	44.7	60.4	69.6	79.7
25	**39G6**	18.6	30.1	41.5	39.7	45.1	69.1	79.8	80.5
25	**39G7**	19.8	34.4	43.3	40.7	46.8	65.8	71.7	74.4
25	**40G4**	17.0	27.2	42.0	40.6	43.8	58.5	67.4	72.7
25	**40G5**	16.9	30.9	42.2	41.2	47.2	62.1	70.6	70.9
25	**40G6**	16.8	22.5	38.9	34.3	36.4	57.8	61.0	65.0
25	**40G7**								
25	**41G6**	20.7	32.2	40.9	38.5	38.3	51.3	49.8	
25	**41G7**	17.8	29.7	40.1	35.2	37.2	51.1	65.1	96.7
26	**39G8**	21.0	38.1	41.2	41.9	46.5	62.5	77.5	83.0
26	**40G8**	22.0	34.9	37.6	37.7	39.3	60.8	78.1	85.0
26	**41G8**		29.3	35.0	32.5	35.4	57.8	57.8	57.8
27	**42G7**		20.8	22.0	25.7	29.3	35.5	41.3	45.4
28	**42G8**		17.6	21.9	21.6	25.9	40.2	41.2	97.5

Tab. 1.1.10. Herring total biomass (t) per age group and rectangle/Sub-division in May/June 1999.

Sub-div.	ICES Rectangle	Age groups 1	2	3	4	5	6	7	8+	3+	Sum
24	**38G2**	5391.6	10239.7	1403.6	1887.6	1547.4	710.2	2520.9	714.3	8783.9	24415.2
24	**38G3**	2674.2	4805.9	1218.6	1495.2	1088.1	268.2	120.1	56.7	4247.0	11727.0
24	**38G4**	476.7	4174.4	1221.5	1184.1	990.1	246.1	137.9	17.1	3796.8	8448.0
24	**39G2**	469.7	1186.2	248.8	275.3	223.5	64.4	119.8	44.6	976.4	2632.4
24	**39G3**	94.7	326.6	89.7	91.7	72.0	13.6	0.0	1.9	268.9	690.2
24	**39G4**	309.8	1076.5	286.3	474.1	292.2	133.0	112.7	18.2	1316.5	2702.7
24	**Total**	**9416.8**	**21809.3**	**4468.5**	**5408.1**	**4213.4**	**1435.5**	**3011.4**	**852.7**	**19389.6**	**50615.6**
25	**37G5**	180.4	2176.8	1385.4	4338.7	6081.0	2524.1	1890.1	854.4	17073.7	19430.9
25	**38G5**	40.2	484.6	308.4	965.8	1353.7	561.9	420.8	190.2	3800.8	4325.5
25	**38G6**	95.8	793.8	389.6	1281.0	1759.4	739.7	677.7	269.5	5117.0	6006.6
25	**39G4**	13.7	48.5	11.2	52.4	51.3	9.1	4.4	1.0	129.5	191.6
25	**39G5**	13.4	256.9	143.1	484.9	596.2	167.7	134.7	60.4	1587.0	1857.4
25	**39G6**	83.1	540.1	208.9	728.5	977.7	409.6	466.5	163.4	2954.5	3577.6
25	**39G7**	1.3	30.2	15.8	48.9	66.7	21.9	26.6	8.1	188.0	219.5
25	**40G4**	29.2	125.3	53.3	177.3	213.3	57.8	40.2	17.6	559.5	714.1
25	**40G5**	18.8	179.5	90.0	320.9	437.6	147.8	120.0	50.4	1166.7	1365.0
25	**40G6**	613.9	1224.4	129.7	667.9	636.0	77.1	40.7	17.3	1568.7	3407.0
25	**40G7**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	**41G6**	1.9	19.4	12.3	34.3	32.4	4.7	1.0	0.0	84.6	106.0
25	**41G7**	2.3	73.4	22.2	71.8	63.0	8.4	6.5	2.8	174.8	250.5
25	**Total**	**1094.0**	**5952.9**	**2770.0**	**9172.4**	**12268.4**	**4729.7**	**3829.2**	**1635.1**	**34404.7**	**41451.6**
26	**39G8**	0.1	30.0	17.7	72.3	92.6	38.8	28.1	18.9	268.4	298.4
26	**40G8**	0.9	52.2	40.4	85.1	110.4	18.1	17.4	6.3	277.7	330.8
26	**41G8**	0.0	55.3	8.2	71.0	81.6	18.8	3.7	3.7	187.0	242.3
26	**Total**	**1.0**	**137.5**	**66.3**	**228.4**	**284.6**	**75.7**	**49.2**	**28.9**	**733.1**	**871.6**
27	**42G7**	0.0	171.4	108.3	477.4	1949.9	646.3	228.6	44.7	3455.2	3626.6
28	**42G8**	0.0	60.2	17.0	55.2	116.7	29.8	7.6	15.7	241.9	302.1
24-28	**Total**	**10511.8**	**28131.3**	**7430.1**	**15341.4**	**18833.0**	**6917.0**	**7126.0**	**2577.0**	**58224.5**	**96867.6**

Table 1.1.11. Estimated numbers (millions) of herring May/June 2001.

Sub-division	Rectangle	Age groups 1	2	3	4	5	6	7	8+	Total
24	**38G2**	10.73	18.14	15.86	13.19	6.21	1.33	3.18	1.15	69.78
24	**38G3**	11.43	13.91	10.87	8.29	4.29	1.02	2.35	0.87	53.02
24	**38G4**	6.05	14.21	10.60	6.70	3.07	0.75	1.36	0.51	43.25
24	**39G2**	11.40	19.28	16.85	14.01	6.60	1.41	3.37	1.22	74.14
24	**39G3**	18.33	51.43	49.80	44.25	19.40	3.77	9.31	3.30	199.59
24	**39G4**	0.51	9.63	14.39	26.03	15.62	4.53	8.11	3.80	82.61
24	**Total**	**58.45**	**126.60**	**118.37**	**112.47**	**55.19**	**12.81**	**27.68**	**453.12**	**511.57**
25	**37G5**	0.47	15.47	3.30	8.07	1.58	5.31	5.92	4.06	44.17
25	**38G5**	0.06	2.47	1.89	5.07	0.95	3.23	3.76	2.27	19.71
25	**38G6**	0.09	2.61	0.17	0.16	0.00	0.01	0.00	0.00	3.05
25	**39G4**	0.22	10.97	6.12	15.52	2.48	8.66	9.84	4.03	57.85
25	**39G5**	0.22	9.33	3.83	9.89	1.48	5.22	6.11	2.98	39.06
25	**39G6**	1.55	64.02	29.56	73.05	12.25	39.45	42.60	20.70	283.16
25	**39G7**	0.00	0.58	0.15	0.34	0.06	0.05	0.15	0.02	1.34
25	**40G4**	0.48	23.65	13.20	33.44	5.35	18.66	21.20	8.70	124.68
25	**40G5**	0.05	3.75	2.44	5.32	0.89	2.70	2.84	1.34	19.35
25	**40G6**	0.00	1.13	0.99	2.21	0.34	1.11	1.34	0.67	7.78
25	**40G7**	0.14	2.31	0.67	1.81	0.66	1.11	1.26	2.09	10.06
25	**41G6**	0.07	1.75	0.12	0.59	0.06	0.14	0.12	0.02	2.86
25	**41G7**	0.10	1.86	0.27	0.29	0.03	0.04	0.05	0.02	2.65
25	**Total**	**3.45**	**139.90**	**62.71**	**155.76**	**26.13**	**85.69**	**95.19**	**565.38**	**568.83**
26	**39G8**	0.00	1.12	0.13	2.38	1.08	1.76	1.91	1.57	9.95
26	**40G8**	0.00	2.65	0.31	4.94	2.39	3.68	4.86	3.77	22.60
26	**41G8**	0.00	9.35	2.22	8.95	3.65	9.08	3.68	1.31	38.23
26	**Total**	**0.00**	**13.12**	**2.66**	**16.27**	**7.12**	**14.52**	**10.45**	**64.14**	**64.14**
27	**42G7**	0.00	2.27	1.30	7.08	3.40	7.97	8.15	0.99	31.14
28	**42G8**	0.00	0.20	0.05	0.15	0.01	0.15	0.19	0.00	0.76
24-28	**Total**	**61.90**	**282.09**	**185.09**	**291.73**	**91.85**	**121.14**	**141.66**	**1083.63**	**1176.44**

Table 1.1.12. Herring mean weight (g) per age group in May/June 2001

Sub-division	Rectangle	Age groups 1	2	3	4	5	6	7	8+	Total
24	**38G2**	30.9	49.6	56.5	70.5	75.1	76.3	72.6	87.7	56.7
24	**38G3**	31.0	48.4	55.8	70.7	75.4	78.8	74.5	90.2	54.3
24	**38G4**	32.3	48.4	54.2	68.6	73.4	83.0	70.2	91.0	54.3
24	**39G2**	30.9	49.6	56.5	70.5	75.1	76.3	72.6	87.8	56.7
24	**39G3**	30.4	50.8	57.1	70.3	74.9	73.9	70.8	85.2	59.1
24	**39G4**	32.0	56.6	62.1	74.8	78.6	85.7	80.2	93.4	72.9
25	**37G5**	23.8	25.4	40.8	53.4	66.0	63.1	65.2	76.5	47.6
25	**38G5**	22.4	36.0	46.3	54.5	62.8	61.8	62.8	73.9	56.7
25	**38G6**	23.6	22.8	24.3	23.8	41.8	46.3	47.5		23.1
25	**39G4**	22.6	32.4	45.9	53.4	58.8	59.4	58.6	65.7	51.4
25	**39G5**	22.9	29.9	45.8	51.6	57.0	59.4	59.5	68.6	49.5
25	**39G6**	25.8	31.7	45.3	51.3	58.1	58.9	60.5	69.7	50.2
25	**39G7**		27.6	41.4	41.8	37.8	48.7	47.0	50.0	36.4
25	**40G4**	22.6	32.4	45.9	53.4	58.8	59.4	58.6	65.6	51.4
25	**40G5**	25.8	36.5	46.5	50.4	55.3	56.3	56.7	63.6	50.0
25	**40G6**	0.0	36.4	47.5	51.4	56.6	57.5	56.4	61.8	51.6
25	**40G7**	25.8	24.7	48.6	62.8	81.1	61.2	68.0	83.5	58.5
25	**41G6**	15.7	24.1	36.5	39.1	43.9	53.0	56.2	58.6	30.8
25	**41G7**	18.4	22.8	32.8	38.3	45.8	38.9	49.7	45.0	26.4
26	**39G8**		39.6	36.8	45.1	43.3	42.7	53.3	70.6	49.4
26	**40G8**		40.9	38.5	47.7	47.7	45.1	53.8	67.9	51.0
26	**41G8**		28.4	29.8	37	38.7	33.8	42.9	57.2	35.1
27	**42G7**		24.3	28.3	32.1	33.0	38.0	44.2	63.9	37.2
28	**42G8**		21.0	28.4	32.4	49.7	42.1	45.6		34.6

Table 1.1.13. Herring total biomass (t) per age group in May/June 2001.

Sub-division	Rectangle	Age groups 1	2	3	4	5	6	7	8+	Total
24	38G2	331.4	900.0	896.1	929.8	466.4	101.3	230.6	100.8	3956.5
24	38G3	354.3	673.3	606.7	585.9	323.1	80.1	175.2	78.5	2879.0
24	38G4	195.3	687.8	574.6	459.5	225.3	62.3	95.8	46.4	2348.5
24	39G2	352.1	956.2	952.1	987.9	495.6	107.6	245.0	107.1	4203.7
24	39G3	557.3	2612.7	2843.7	3110.7	1452.8	278.6	659.5	281.2	11795.8
24	39G4	16.2	545.3	893.9	1946.9	1227.7	387.9	650.3	355.1	6022.3
24	**Total**	**1806.6**	**6375.3**	**6767.1**	**8020.7**	**4190.9**	**1017.8**	**2056.4**	**969.1**	**31203.9**
25	37G5	11.2	392.9	134.6	430.8	104.3	335.0	385.7	310.5	2102.5
25	38G5	1.4	88.9	87.7	276.5	59.6	199.7	236.3	167.7	1117.6
25	38G6	2.1	59.5	4.1	3.9	0.2	0.4	0.1	0.1	70.5
25	39G4	5.1	355.5	281.0	828.5	146.0	514.2	576.4	264.9	2973.5
25	39G5	5.0	278.9	175.3	510.5	84.4	310.3	363.6	204.4	1933.5
25	39G6	40.0	2029.3	1339.0	3747.3	711.5	2323.6	2577.3	1443.7	14214.6
25	39G7	0.0	16.0	6.1	14.3	2.3	2.3	6.8	1.0	48.8
25	40G4	10.9	766.3	605.7	1785.6	314.7	1108.2	1242.4	571.0	6408.6
25	40G5	1.4	136.9	113.7	268.2	48.9	152.3	161.2	85.2	967.5
25	40G6	0.0	41.1	46.9	113.8	19.2	63.5	75.7	41.4	401.4
25	40G7	3.7	57.0	32.4	113.9	53.6	67.8	85.9	174.6	588.5
25	41G6	1.1	42.1	4.5	23.2	2.5	7.2	6.9	0.7	88.1
25	41G7	1.9	42.4	8.8	11.0	1.3	1.6	2.3	0.9	70.0
25	**Total**	**83.8**	**4306.8**	**2839.8**	**8127.5**	**1548.5**	**5086.1**	**5720.6**	**3266.1**	**30979.2**
26	39G8	0.0	44.4	4.9	107.4	46.9	75.1	102.0	110.8	491.5
26	40G8	0.0	108.2	12.1	235.8	114.0	165.8	261.7	256.1	1152.6
26	41G8	0.0	265.4	66.0	331.1	141.1	307.0	157.9	74.9	1341.9
26	**Total**	**0.0**	**418.0**	**83.0**	**674.3**	**302.0**	**547.9**	**521.6**	**441.8**	**2988.6**
27	42G7	0.0	55.1	36.8	227.1	112.1	302.7	360.0	63.3	1158.4
28	42G8	0.0	4.3	1.4	5.0	0.7	6.2	8.7	0.0	26.3
24-28	**Total**	**1890.4**	**11159.5**	**9728.1**	**17054.6**	**6154.2**	**6960.7**	**8667.3**	**4740.3**	**66356.4**

Tab. 1.1.14. Estimated model parameters and characteristics for the regression of CPUE versus oxygen saturation.

COD, Bornholm Basin , P<0.0001, r^2=0.38					
Parameter	Estimate	Std. Err.	Confidence	limits	Threshold
A	59.9773	13	35	85	
p_{50}	19.3385	4	12	27	**16 %**
COD, Gotland Basin , P=0.0025, r^2=0.47					
Parameter	Estimate	Std. Err.	Confidence	limits	Threshold
A	77.7902	20	36	119	
p_{50}	28.5702	4	21	37	**25 %**
Herring, Bornholm Basin , P<0.0001, r^2=0.58					
Parameter	Estimate	Std. Err.	Confidence	limits	Threshold
A	1588.2	221	1142	2035	
p_{50}	55.0985	2	52	58	**50 %**
Herring, Gotland Basin , P<0.0001, r^2=0.58					
Parameter	Estimate	Std. Err.	Confidence	limits	Threshold
A	2557.1	418	1701	3413	
p_{50}	15.9931	9	-1	33	**10 %**
Sprat, Bornholm Basin , P<0.0001, r^2=0.58					
Parameter	Estimate	Std. Err.	Confidence	limits	Threshold
A	11624	1613	8359	14889	
p_{50}	45.7014	2	42	50	**40 %**
Sprat, Gotland Basin , P=0.0112, r^2=0.27					
Parameter	Estimate	Std. Err.	Confidence	limits	Threshold
A	4071.4	1304	1400	6743	
p_{50}	21.8537	3	15	29	**18 %**

Tab. 1.1.15. Percentage of age-group 2 cod in Latvian bottom trawl catches in the central Gotland Basin (Sub-division 28) and the southern Gotland Basin (Sub-division 26 north) in quarters 1, 2 and 4 1981-1989 (- : no survey data available).

	Sub-division 28			Sub-division 26		
year/quarter	1	2	4	1	2	4
1981	66.4	25.2	66.4	-	7.9	-
1982	56.7	26.1	54.0	64.6	47.7	59.5
1983	7.4	32.0	30.3	18.6	17.8	23.6
1984	6.3	9.1	25.4	13.9	7.2	43.0
1985	45.3	15.1	33.9	22.5	31.3	31.6
1986	54.1	42.5	80.6	-	31.0	64.3
1987	55.6	78.8	69.3	48.2	63.1	-
1988	25.0	44.4	74.8	63.2	36.8	51.3
1989	15.0	17.5	43.2	4.7	5.1	54.5
Average	36.9	32.3	53.1	33.7	27.5	46.8

Tab. 1.1.16. Stock sizes of sprat (millions) per Sub-division in the Baltic derived from hydroacoustic surveys.

Sub-division	October 1998	May/June 1999	October 1999
24	4390	5256	1354
25	16517	38943	9992
26	53973	62924	25636
27	41788	-	34607
28	63895	-	36411
29 south	11495	-	56299

Tab. 1.1.17. Proportion (%) of the sprat stock in Sub-division (SD) 25 concentrating within the 60m isobath according to historic hydroacoustic surveys.

Month	Year	Proportion within > 60m
May/June	**1979**	65.3
	1981	50.0
	1983	41.2
	1983	58.8
	1984	44.3
	1985	73.7
	1986	36.3
July/August	**1981**	14.0
	1983	17.8
	1987	21.3
	1988	23.9

Table 1.2.1. Macroscopic visual scale for sprat proposed by Alekseev and Alekseeva (1996)

Stage	State	Females	Males
I	Juvenile	Gonads are thin, thread-like, colorless and transparent. Sex of fish is not distinguishable by naked eye.	
II	Resting (non-mature)	Ovaries are small, tubular, slender, **yellow-orange**. Oocytes are **not visible by eye**. If the color is dark violett: stage **VI-II**!!!	Testes are thin, flatten, half-transparent and greyish.
III	Ripening	Ovaries increasing the size and at the end of the stage **occupy up to 2/3 of body cavity**. In the beginning of stage oocytes are half-transparent, but at the end of stage non-transparent, yellow. Only at the caudal end (near the ass) there might be some reddish area. Non-transparent and yellow oocytes are **seen by naked eye** through the membrane of ovaries. Diameter of oocytes is 0.2 mm in the beginning of stage and 0.5 mm – at the end of stage. Sub-stages of stage III (differentiation of the ripening females from those who are close to the mature stage) are no longer separated. To distinguish between stage III and IV use the **size** of the oocytes. Oocytes in stage IV are slightly bigger! III is separated from VI-III with the help of the **color** of the ovary (VI-III: reddish violet).	Size of testes has increased and at the end of stage III they occupy most of body cavity. Testes are elastic on touch. At the end of stage, they are white (though real white ones are hardly available). To distinguish from stage IV, a **cross-section** of testes can be done. **Overrun' (overflow) and exude of milt should not occur, the form should be maintained.** III has also a different shape of the testes with a **triangular form**.
IV	Mature (ripe)	Ovaries occupy all empty space in body cavity. Non-transparent oocyte diameter is 0.5-0.6 mm, so oocytes are **slightly bigger than in III**. The color of the ovary is **light yellow**, not reddish!	Testes occupy all body cavity, are elastic and **white**. In cross-section, they '**overrun**' (overflow) exuding thick milk.
IV-V	Pre-spawning	Ovaries occupy all empty space in ventral cavity firmly pressing on all other organs. Through the membrane of ovaries are seen **large** (diameter 0.7-1.0 mm) and transparent (**hydrated) oocytes**. In ovary they are evenly distributed between different size ripening and non-transparent oocytes. There are no eggs available in ovaries cavity. It is **very important** to distinguish between IV-V and **VI-IVh** (a new invention!). IV-V is mostly yellow in contrast to VI-IV which is red-violet (but both are of course a bit transparent).	
V (VI-V)	Spawning	Slight pressure upon the belly extrudes eggs from the genital opening (press before cutting the fish!). **Running** during the day is really seldom!	Slight pressure upon the belly **extrudes thin milk** from the genital opening, so press **before cutting** the fish!!!
VI-III	Partly spawned - ripening	Ovaries are similar to the stage III, but have **reddish-violet** color. Ovaries are soft on touch. In cross-section of ovaries in ovaries cavity are seen separate, not spent eggs. Use the **size** of oocytes to differenciate between VI-III and VI-IV	
VI-IV	Partly spawned – mature	Ovaries are similar to stage IV but reddish-violet. In ovaries cavity can be seen separate, not spent eggs. Do not judge by size of ovary but again by size of oocytes!	Testes are similar to stages III and IV, but **smaller**, soft and **unevenly colored**: Milk is remaining in the upper part (**white areas**), reddish or brownish spots occur.
VI-IVh	NEW!	**New invention** to separate between first time spawners (IV-V) and those which are entering from VI-IV: Similar to IV-V (see above) but the color is **red-violet**!!!	
VI	Spent (Spawned)	Like an early stage III, but Ovaries are **very flabby** (and small), mainly **dark red**, half-transparent. **Small number** of remaining yellow oocytes can be seen through membrane of ovaries. Cross-section of ovaries cavity has large opening in which can be seen separate, not spent or remaining eggs.	Testes are **small**, soft and **flabby**. Colors of testes are red-brawn frequently with white spots. In cross-section, they not 'overrun' (overflow) but small amount of remaining milk is exuded.
VI-II	Post-spawning (Recovering)	**Similar to stage II**: Ovaries are small and half-transparent but the color is **still dark red**. No oocytes can be seen by naked eye.	Testes are small, dense, elastic, non-transparent and **brownish**. In cross-section they **maintaining the shape** and not 'overrun' (overflow).

Table 1.2.2: Data sets provided by project partners to estimate maturity ogives and sex ratios of Baltic sprat (Sub-div. 22-32) according to ICES Subdivisions and time periods.

Sub-division	Period	Data type (commercial/ Trawl-Survey / Hydroacoustic)	Number of data sets	Data Source (e.g. Institute / Country)
28	1995-2000	Commercial	28	EMI / Estonia
29	1980-1985	Commercial	44	EMI / Estonia
29	1995-2000	Commercial	93	EMI / Estonia
32	1980-1985	Commercial	102	EMI / Estonia
32	1995-2000	Commercial	129	EMI / Estonia
26	1st quarter 1996	Commercial	1	AtlantNIRO / Russia
26	2nd quarter 1996	Commercial	1	AtlantNIRO / Russia
26	1st quarter 1997	Commercial	1	AtlantNIRO / Russia
26	2nd quarter 1997	Commercial	1	AtlantNIRO / Russia
25	4th quarter 1997	Commercial	1	DIFRES / Denmark
25	1st quarter 1998	Commercial	3	DIFRES / Denmark
26	1st quarter 1998	Commercial	1	DIFRES / Denmark
26	1st quarter 1999	Commercial	1	AtlantNIRO / Russia
29 / 30	1st quarter 1998	Commercial	2	DIFRES / Denmark
25	2nd quarter 1998	Trawl-Survey Dana	1	DIFRES / Denmark
26	2nd quarter 1998	Commercial	1	AtlantNIRO / Russia
25	3rd quarter 1998	Trawl-Survey Alkor	2	DIFRES / Denmark
26	4th quarter 1998	Commercial	1	DIFRES / Denmark
25	1st quarter 1999	Commercial	3	DIFRES / Denmark
26	1st quarter 1999	Commercial	2	DIFRES / Denmark
26	1st quarter 1999	Commercial	1	AtlantNIRO / Russia
25	2nd quarter 1999	Trawl-Survey Alkor	2	DIFRES / Denmark
25	3rd quarter 1999	Trawl-Survey Alkor	1	DIFRES / Denmark
26	4th quarter 1998	Commercial	1	DIFRES / Denmark
25	1999	Trawl-Survey / Hydroacoustic)	5	IfM Kiel / Germany
26	1999	Hydroacoustic	1	IfM Kiel / Germany
27+28	1999	Hydroacoustic	1	IfM Kiel / Germany
25	2000	Trawl-Survey	6	IfM Kiel / Germany

Tab. 1.2.3. Number of sprat sampled for sex determination and maturity staging by year, month and ICES Sub-division.

Year	Quarter	Sub-div. 25	Sub-div. 26	Sub-div. 27+28	Sub-div. 29	Sub-div. 32	Total 25-32
1980	Sum				600	1800	2400
1981	Sum				300	1700	2000
1982	Sum				1100	2350	3450
1983	Sum				400	1050	1450
1984	Sum				1350	1300	2650
1985	Sum				200	1250	1450
1995	1st quarter			202	1180	1390	2772
	2nd quarter			246	300	640	1186
	Sum			448	1480	2030	3958
1996	1st quarter		20016		750	600	1350
	2nd quarter		4589	187		1050	1237
	Sum			187	750	1650	2587
1997	1st quarter		22422	200	600	1111	1911
	2nd quarter		7892	52	850	1000	1902
	4th quarter	117					117
	Sum	117		252	1450	2111	3930
1998	1st quarter	429	16200	300	1131	990	19050
	2nd quarter	193	4362	367	1400	970	7292
	3rd quarter	118					118
	4th quarter			87			87
	Sum	740	20562	754	2531	1960	26547
1999	1st quarter	470	2689	300	1454	1350	6263
	2nd quarter	5273	270	211	800	1020	7574
	3rd quarter	6102					6102
	4th quarter		119				119
	Sum	11845	3078	511	2254	2370	20058
2000	1st quarter			300	300	1200	1800
	2nd quarter	1819	276	128	550	1100	3873
	3rd quarter	574	79				653
	Sum	2393	355	428	850	2300	6326

Tab. 1.2.4. Index scale of Maier* to stage the reproductive status of female fishes.

Stage	Macro- and microscopic characters staging ovarian maturation
I	Juvenile Ovary glassy transparent, seldom reddish translucent; small with tight walls and small lumen. The eggs are not visible to the naked eye; using a stereomicroscope, the ovary wall appears smooth and homogeneous, at most slightly dotted; microscopically the eggs appear as completely glassy transparent, tightly packed polygonal cells of different sizes.
II	Resting Ovary blurred translucent, of reddish to reddish-grey color; small with tight walls, lumen is filled with fluid and clearly distinguishable. Using a stereomicroscope, single eggs are seen as rounded, translucent grains among juvenile eggs looking as in Stage I.
III	***Preparation*** Ovary almost completely opaque, reddish-grey to dark orange in colour; slightly larger than in II, less tight; rich in blood vessels; lumen larger. Few to numerous larger, opaque, orange eggs, in which yolk formation has started, are visible to the naked eye.
IV	Aggregation Ovary completely opaque, orange to reddish-white; comparatively easy to distinguish, reaching at most half of its definitive length; very plump, later brittle; lumen still distinct. All eggs, that will be spawned, are now filled with yolk and as so light orange to reddish-white and opaque; the eggs are so tightly packed that they shape each other polygonal.
V	Stretching Ovary opaque, orange to reddish-white; has reached the definitive length and thickness (thus named stretching stage); very plump, brittle, lumen very compressed. The eggs appear as in Stage IV, but have again become completely round; ripe, glassy translucent eggs may already appear sporadically.
VI	Spawning Ovary translucent grey-reddish, sometimes still with few opaque orange to whitish-grey patches; length as in Stage V; very plump, but give way to pressure; lumen is filled with fluid spawn. Most eggs have become glassy transparent and flow easily at pressure, but also patches with opaque eggs as in Stage V are present.
VII	Half spent Ovary grey to dark red, translucent; somewhat shortened; walls flabby, rich in blood; lumen very large, filled with fluid eggs and a lot of liquid. No opaque eggs (as in Stage V) are present any longer; most of the glassy eggs have already been spawned, the remaining ones lie in the lumen.
VIII	Spent The ovary dark reddish translucent; considerably shortened; walls very flabby, wrinkled often and rich in blood. Lumen very large with lots of fluid, only traces of spawn left; approaching Stage II. From the white eggs, only scattered remains may still be present, mostly shrunken and under resorbtion; otherwise as Stage II.

* Translated from Maier (1908) (from Tomkiewicz *et al.* 2003).

Tab. 1.2.5. Number of fish sampled for timing and duration of spawning and spawning frequency of sprat by year, month and ICES Sub-division.

Year	Month	Sub-div. 25	Sub-div. 26	Sub-div. 27-28	Sampling type	Total
1995	April	230			trawl survey	230
1996	April	755			trawl survey	755
1998	April	114			commercial	114
1999	April	1178			trawl survey	1178
	May	1738			trawl survey	1738
	June	2083	270	211	hydro-acou.	2564
	July	4223			trawl survey	4223
	August	1788			trawl survey	1788
	Sum	12109	270	211		12590

Tab. 1.2.6. Proportion mature at length of Baltic sprat in ICES Sub-division 25, 26 and 27+28.

Sub-division 25

Year	Month			Length class 8	9	10	11	12	13	14	15
1999	June	Male	Proportion	0.00	0.87	0.98	0.99	1.00	0.99	0.94	1.00
			Number	1	86	292	248	126	111	31	1
		Female	Proportion	0.00	0.00	0.68	0.91	1.00	1.00	0.98	1.00
			Number	2	19	125	164	289	302	233	55
		Combined	Proportion	0.00	0.71	0.89	0.96	1.00	1.00	0.98	1.00
			Number	3	105	417	412	415	413	264	56
		Sex ratio	Prop. females	0.67	0.18	0.30	0.40	0.70	0.73	0.88	0.98

Sub-division 26

Year	Month			Length class 9	10	11	12	13	14
1999	June	Male	Proportion	0.89	0.98	0.97	1.00	1.00	1.00
			Number	45	41	34	23	12	1
		Female	Proportion	0.33	0.75	1.00	1.00	1.00	0.00
			Number	6	20	27	36	25	0
		Combined	Proportion	0.82	0.90	0.98	1.00	1.00	1.00
			Number	51	61	61	59	37	1
		Sex ratio	Prop. females	0.12	0.33	0.44	0.61	0.68	0.00

Sub-division 27+28

Year	Month			Length class 9	10	11	12	13	14
1999	June	Male	Proportion	0.80	0.95	1.00	1.00	1.00	0.86
			Number	5	20	22	11	16	7
		Female	Proportion	0.44	0.55	0.83	1.00	1.00	0.92
			Number	9	20	18	28	23	24
		Combined	Proportion	0.57	0.75	0.93	1.00	1.00	0.90
			Number	14	40	40	39	39	31
		Sex ratio	Prop. females	0.64	0.50	0.45	0.72	0.59	0.77

Tab. 1.2.7. Sprat maturity ogives per age for ICES Sub-division 26 1996-1999 first and second quarter.

Year	1996							
Quarter	I				II			
	females		males		females		males	
AGE	immature	mature	immature	mature	immature	mature	immature	mature
1	3884	919	2404	919	279	56	483	186
2	315	3460	1258	1887	67	704	17	1392
3	43	1127	303	823	0	351	0	313
4	30	1045	239	508	0	308	0	133
5	34	461	0	103	0	159	0	51
6	25	163	0	25	0	60	0	20
7	0	33	0	8	0	5	0	5
8	0	0	0		0		0	
9	0	0	0		0		0	
Measured	4331	7208	4204	4273	346	1643	500	2100
AGED	208		157		203		190	
Year	1997							
Quarter	I				II			
	females		males		females		males	
AGE	immature	mature	immature	mature	immature	mature	immature	mature
1	551	0	138	83	158	53	105	0
2	5445	1210	3544	2593	239	2512	0	1555
3	1803	2352	470	1333	0	1260	0	802
4	472	669	79	275	0	219	0	493
5	432	288	41	164	0	387	0	70
6	317	86	29	29	0	39	0	0
7	13	6	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0
Measured	9033	4611	4301	4477	397	4470	105	2920
AGED	221		123		55		33	
Year	1998							
Quarter	I				II			
	females		males		females		males	
AGE	immature	mature	immature	mature	immature	mature	immature	mature
1	2209	0	2209	1657	650	124	310	31
2	50	149	17	249	0	78	13	103
3	0	1658	107	2941	0	820	0	678
4	73	1314	73	1605	0	754	0	452
5	0	631	0	486	0	44	0	74
6	0	332	0	249	0	69	0	104
7	0	14	0	42	0	35	0	23
8	0	45	0	11	0	0	0	0
9	0	0	0	8	0	0	0	0
Measured	2332	4143	2406	7248	650	1924	323	1465
AGED	96		127		95		83	
Year	1999				1999			
Quarter	1				2			
	females		males		females		males	
AGE	immature	mature	immature	mature	immature	mature	immature	mature
1	10	0	36	0	38	2	32	9
2	128	275	41	291	609	1196	216	1088
3	15	120	0	135	70	296	17	192
4	67	291	15	446	53	596	26	291
5	67	210	6	195	14	308	7	68
6	14	20		6	0	37	0	0
7	5	25		25	4	42	0	0
8	4	5			3	6	0	0
10				5				
Measured	310	946	98	1103	791	2483	298	1648
AGED	232		172		314		175	

Table 1.2.8. Histological characters staging ovaries. For character abbreviations see text.

Histological character[1]	Histological maturity stage									
	I	II	III	IV	V	VI	VII	VIII	IX	Xa/b
NU1	$\boxed{+++}$	+++	+					$\boxed{++}$	+++	•
CNR		$\boxed{++}$	+					++	$\boxed{+++}$	•
CH1		+	+++					+	+	•
CA			$\boxed{+++}$							•
NU2			++	+++	+++	++	+			•
VT1			++							•
VT2			+							•
VT3+CH2			•	$\boxed{+++}$	$\boxed{+++}$	$\boxed{++}$	+			•
NE				+	+	+	+			•
FG					$\boxed{+}$	$\boxed{++}$	$\boxed{++}$			•
HYD					$\boxed{+}$	$\boxed{++}$	$\boxed{++}$	+		•
EF			+*		$\boxed{+}$	$\boxed{++}$	$\boxed{+++}$	$\boxed{+++}$		•
AT			+**	•	•	•	•	•	•	•
ERE			•	•	•	•	•	•	$\boxed{+}$	$\boxed{+++}$

[1]Relative abundance of characters: +++ abundant, ++ common, + scarce, • potential; Stage indicator(s): □ must be present; ⬚ at least one of the marked characters should be present. * Present in Stage III:VIII, ** present in Stage III:IX.

Table 1.2.9. Histological maturity scale based on the most progressed features.

Phase	Stage	Histological criteria
Juvenile	I	Oocytes in perinuclear stage with large circular nuclei and peripheral nucleoli in most progressed ovaries. *d* <80µm*.
Preparation	II	Oocytes with circumnuclear ring and nuclei with attached nucleoli. *d*: 90-160µm.
Ripening	III	Oocyte recruitment: Oocytes with cortical alveoli, initial chorion, detached peripheral nucleoli progressing to vitellogenesis, but yolk granules not entirely filling cytoplasm. *d*: 170-290µm; *n/o*: > 0.4**.
	IV	Late vitellogenesis: Yolk granules entirely fill cytoplasm and expand oocytes; nucleus central circular to slightly eccentric irregular. Enlarged chorion. *d*: 300-530µm; *n/o*: < 0.4.
Spawning	V	Initiation of spawning: Abundant vitellogenic oocytes as in IV, but round and larger; single oocytes in final maturation, hydrating oocytes or post-ovulatory follicles exist. *d*: 500-970µm.
	VI	Main spawning period: Vitellogenic oocytes as in V, oocytes in final maturation, oocytes in hydration and post-ovulatory follicles abundant. *d*: 510-1000µm.
	VII	Cessation of spawning: Post-ovulatory follicles abundant, final maturation and hydrating oocytes frequent, vitellognic oocytes scarce or absent. *d*: 450-930µm.
Regeneration	VIII	Spent: Post-ovulatory follicles abundant among perinuclear or circumnuclear stage oocytes, residual eggs or atretic vitellogenic oocytes may be present. *d*: 110-140µm.
	IX	Resting: Oocytes in perinuclear or circumnuclear stage as in II, but residual eggs or atretic vitellogenic oocytes present. d: 140-170µm.
Degeneration	X	a: Malfunction due to high density of residual eggs encapsulated by fibroblast and macrophages among normal developing oocytes. b: Other abnormalities.

[*] *d* = oocyte diameter limits (measurements from paraplast sections) given as 0.5 and 0.95 percentiles;
[**] *n/o* = ratio nucleus:oocyte diameter

Table 1.2.10a. Macroscopic maturity scale for females corresponding to histological phases and stages.

Phase	Stage	Macroscopic criteria
Juvenile	I	Ovaries emerge as tiny, paired organs close to bladder; glassy transparent to orange-reddish translucent in larger specimens. L_T > 30 cm*; I_G < 1**.
Preparation	II	Ovaries small, but easily distinguishable posterior in body cavity; soft with even surface (flattens on a solid sheet); blurred translucent, reddish-orange. L_T: 25-60cm; I_G < 1.5.
Ripening	III	Oocyte recruitment: Ovaries still small and restricted to posterior body cavity; firmer than II and roe shaped (keep form on a solid sheet), surface uneven; opaque orange-red to dark orange with greyish cast in large females. Tiny opaque oocytes emerge towards end of stage. L < 30 cm; I_G: 1-7.5.
	IV	Late vitellogenesis: Ovaries enlarged to mid body cavity; plump and firm with prominent blood vessels; opaque, orange to creamy yellow. Oocytes clearly visible, densely packed. I_G: 3-14.
Spawning	V	Initiation of spawning: Ovaries extending into anterior body cavity; distended and soft; opaque, orange to creamy yellow. Single glassy, hydrating oocytes among abundant opaque, vitellogenic oocytes (as in IV, but round and larger). Viscous fluid or hydrated eggs in lumen may occur. I_G 12-25.
	VI	Main spawning: Ovaries fill most of body cavity; very distended and soft; appear granulat+ed orange- to reddish-grey from mixture of opaque and glassy oocytes. Lumen contains viscous fluid in excess or hydrated eggs. I_G: 15-60.
	VII	Cessation of spawning: Ovaries shrunk to posterior body cavity; flabby with prominent blood vessels; unclear reddish-grey. Hydrated oocytes present; but rarely opaque oocytes. Lumen with excess fluid and frequently hydrated eggs. I_G: 3-8.
Regeneration	VIII	Spent: Ovaries contracted; slack with greyish cast; rich in blood vessels; dim translucent reddish-grey. Vitellogenic oocytes absent, but single hydrated eggs or atretic oocytes (opaque, irregular granules) may occur. I_G normally 2-3; with atresia up to 10.
	IX	Resting: Ovaries as in II, but with signs of previous spawning; e.g greyish cast and somewhat uneven walls; blurred translucent, reddish-grey, but more granulated and opaque than in II. I_G: 1-3.
Degeneration	X	a: Ovaries with fibrous tissue formation; affected areas compact and hard, brownish-yellow opaque; non-affected parts with normal development; L_T > 65 cm. b: Other abnormalities.

* L_T =*total length;* ** I_G = gonadosomatic index, both given as observed minimum and maximum values.

Tab. 1.2.10b. Macroscopic maturity scale for males corresponding to the female phases and stages.

Phase	Stage	Macroscopic criteria
Juvenile	I	Juvenile: Testes emerge as a pair of thin strings along air bladder. Lobules tiny, glassy transparent to reddish translucent in larger specimens. L_T < 30 cm*; I_G < 0.1**.
Preparation	II	Preparation: Testes small, but distinguishable along air bladder. Lobules small, blurred translucent and reddish. L_T: 20-50cm; I_G < 0.1-0.5.
Ripening	III	Early spermatogenesis: Testes still small, close to air bladder. Lobules plump and soft, rich in blood vessels, completely or partially opaque, reddish. L_T > 20 cm; I_G: 0.5-6.
	IV	Late spermatogenesis: Testes enlarged and prominent dorsal in body cavity; Lobules plump and brittle; reddish-white. Empty, transparent spermaducts with prominent blood vessels; no sperm release. I_G: 1-18.
Spawning	V	Initiation of spawning: Testes extending into ventral part of body cavity. Lobules distended and brittle, opaque creamy-white. Spermaducts filled with viscous semen and a viscous droplet may be released from vent. I_G 3-22.
	VI	Main spawning: Testes large and prominent in body cavity (as in V). Lobules still plump, but soft; completely opaque, whitish. Spermaducts filled with fluid, milky semen that easily flows from vent. I_G: 3-25.
	VII	Cessation of spawning: Testes shrunk to dorsal part of body cavity; soft and flabby. Lobules almost empty, opaque, reddish-white. Spermaducts still with fluid semen that easily flows from vent. I_G: 0.5-4
Regeneration	VIII	Spent: Testes contracted, close to air bladder; rich in blood vessels. Lobules empty, flabby, reddish potentially with a greyish cast. Spermaducts with signs of previous distension, often with visible remains of semen I_G < 1.5.
	IX	Resting: Testes small (as in Stage II), but with signs of previous spawning; e.g. lobules slightly larger than in II; spermaducts often with greyish cast. I_G: < .5.
Degeneration	X	a Testes with adipose tissue formation; affected parts undeveloped, hard, yellowish; non-affected parts with normal development. Observed in males from 50 cm. b Other abnormalities.

Tab. 1.2.11. Proportions of adult females in different spawning stages in ICES Sub-division 25. Data from trawl surveys in April 1995, 96, 98 and 99.

Proportions from adult females	Apr 95	Apr 96	Apr 98	Apr 99
pre-spawning cond.	0.08	0.17	0.45	0.62
spawning cond.	0.92	0.82	0.55	0.37
post-spawning cond.	0.00	0.01	0.00	0.01

Table 1.3.1. Estimated length (cm), weight (g) and potential fecundity for Baltic cod of different ages 2-8+, and estimated egg size (ES) (mm) and salinity of neutral buoyancy (B) (psu) for each batch during spawning.

Age (yr)	2		3		4		5		6		7		8+	
Length (cm)	28		45		56		65		73		79		92	
Weight (g)	546		1186		1961		2958		4264		5608		10157	
Potential fecundity Kraus (1997)	448395		986456		1644569		2497471		3621796		4784828		8750931	
Batch no.	ES	B	ES	B	ES	B	ES	B	ES	B	ES	B	ES	B
1	1.487	15.77	1.554	14.91	1.597	14.36	1.633	13.90	1.664	13.51	1.688	13.20	1.739	12.55
2	1.487	15.77	1.554	14.91	1.613	14.16	1.649	13.70	1.681	13.29	1.705	12.98	1.756	12.33
3	1.487	15.77	1.554	14.91	1.621	14.05	1.657	13.59	1.689	13.19	1.713	12.88	1.765	12.21
4	1.487	15.77	1.554	14.91	1.629	13.95	1.666	13.48	1.697	13.08	1.722	12.76	1.774	12.10
5	1.487	15.77	1.554	14.91	1.637	13.85	1.674	13.38	1.706	12.97	1.730	12.66	1.782	12.00
6	1.487	15.77	1.554	14.91	1.645	13.75	1.682	13.27	1.714	12.87	1.739	12.55	1.791	11.88
7	1.487	15.77	1.554	14.91	1.645	13.75	1.682	13.27	1.714	12.87	1.739	12.55	1.791	11.88
8	1.480	15.86	1.546	15.01	1.637	13.85	1.674	13.38	1.706	12.97	1.730	12.66	1.782	12.00
9	1.465	16.05	1.531	15.21	1.629	13.95	1.666	13.48	1.697	13.08	1.722	12.76	1.774	12.10
10	1.450	16.24	1.515	15.41	1.621	14.05	1.657	13.59	1.689	13.19	1.713	12.88	1.765	12.21
11	1.435	16.43	1.500	15.60	1.605	14.26	1.641	13.80	1.672	13.40	1.696	13.10	1.748	12.43
12	1.420	16.62	1.484	15.81	1.589	14.46	1.625	14.00	1.656	13.61	1.680	13.30	1.730	12.66
13	1.405	16.82	1.469	16.00	1.565	14.77	1.600	14.32	1.631	13.93	1.654	13.63	1.704	12.99
14	1.390	17.01	1.453	16.20	1.541	15.08	1.576	14.63	1.606	14.25	1.629	13.95	1.678	13.33
15	1.375	17.20	1.437	16.41	1.517	15.38	1.551	14.95	1.581	14.57	1.604	14.27	1.652	13.66
16	-	-	-	-	1.493	15.69	1.527	15.26	1.556	14.89	1.578	14.60	1.626	13.99
17	-	-	-	-	1.469	16.00	1.502	15.58	1.531	15.21	1.553	14.92	1.600	14.32
18	-	-	-	-	1.445	16.30	1.478	15.88	1.506	15.52	1.528	15.24	1.574	14.66
19	-	-	-	-	1.421	16.61	1.453	16.20	1.481	15.84	1.502	15.58	1.548	14.99
20	-	-	-	-	1.397	16.92	1.429	16.51	1.456	16.16	1.477	15.90	1.522	15.32

Table 1.3.2. Average duration of spermatozoa mobility and spermatocrit at different times during the spawning period for individual cod males.

day	12 psu	15 psu	spermatocrit
1-10	0.6±0.6	3.3±2.3	48.1±13.3
	n=34	n=34	n=20
11-20	1.9±1.1	11.0±5.4	53.6±6.0
	n=11	n=11	n=8
21-30	1.9±1.5	6.6±4.5	45.6±11.1
	n=18	n=18	n=24
31-40	1.9±1.5	5.9±4.4	55.6±12.6
	n=27	n=27	n=23
41-50	(0.8±0.7)	(3.9±6.6)	(53.2±18.7)
	n=7	n=7	n=5
51-60	2.4±2.8	6.0±5.1	47.1±14.7
	n=16	n=16	n=11
61-70	0.9±0.9	4.3±4.8	49.8±16.8
	n=13	n=13	n=7
average	1.5±0.7	5.8±2.6	50.4±3.8

Table 1.3.3. Relationships between spermatozoa mobility and cod male size and condition at different times during the spawning season; onset of spawning (start), peak spawning (day 20-40) and late spawning (day 40-60).

salinity	length/ weight	time	df	r	t	p
12 psu	length	start	17	0.138	0.577	0.572
		peak	19	0.450	2.20	0.040
		late	19	0.517	2.63	0.016
	weight	start	17	0.084	0.36	0.725
		peak	19	0.501	2.52	0.021
		late	19	0.530	2.73	0.013
15 psu	length	start	17	0.032	0.15	0.881
		peak	19	0.540	2.80	0.011
		late	19	0.540	2.80	0.011
	weight	start	17	0.045	0.20	0.844
		peak	19	0.514	2.61	0.017
		late	19	0.591	3.19	0.005
12 psu	Fulton´s	start	17	0.457	1.43	0.171
		peak	19	0.100	0.04	0.972
		late	19	0.045	0.14	0.888
	HSI	start	13	0.192	0.71	0.494
		peak	13	0.095	0.35	0.730
		late	13	0.141	0.52	0.615
15 psu	Fulton´s	start	17	0.197	0.43	0.674
		peak	19	0.333	0.54	0.596
		late	19	0.032	0.08	0.939
	HSI	start	13	0.167	0.62	0.549
		peak	13	0.089	0.32	0.755
		late	13	0.217	0.80	0.438

Table 1.3.4. Relationships between female parameters (length, weight and condition) and diameter (mm) and specific gravity (g/cm3) of Baltic sprat eggs, sampled by stripping and artificial fertilisation, from females caught in the Bornholm Basin (BB), Gdansk Deep (GD) and the Gotland Basin (GB) in April and in late May/early June.

	BB. GD & GB May/June		BB April		BB April and BB. GD & GB May/June	
	egg size	egg specific gravity	egg size	egg specific gravity	egg size	egg specific gravity
Female length	df=36 t=2.19 p=0.035	df=37 t=-2.42 p=0.021	df=12 t=1.59 p=0.139	df=15 t=-2.54 p=0.024	df=49 t=2.46 p=0.017	df=50 t=-1.64 p=0.107
Female weight	df=36 t=3.14 p=0.003	df=37 t=3.22 p=0.003	df=12 t=1.73 p=0.112	df=15 t=-1.84 p=0.088	df=49 t=3.28 p=0.003	df=50 t=-1.57 p=0.123
Female gutted weight	df=36 t=3.56 p=0.001	df=37 t=-3.49 p=0.001				
Female condition Fulton´s cf	df=36 t=1.90 p=0.065	df=37 t=-1.32 p=0.194	df=12 t=0.290 p=0.777	df=15 t=0.49 p=0.630	df=49 t=1.63 p=0.109	df=50 t=0.29 p=0.777
Female condition gutted Fulton´s cf	df=36 t=2.58 p=0.030	df=37 t=-1.51 p=0.139				

Tab. 1.3.5. Parameters measured in running-ripe female cod as well as the effect parameters measured on fertilized eggs and hatched larvae from the respective females, 1999. CI- condition index (gutted weight/length3 x100). HSI - hepato-somatic index (liver weight/fish weight x 100). GSI - gonado-somatic index (gonad weight/ fish weight x 100).

Female no.	Age	CI	HSI	GSI	larvae hatched %	survival after hatch %	Larvae growth (day 0-10) %	egg size mm	larvae length at hatch mm
1	6	0.93	3.09	20.2	65.0	100	13.1	1.69	2.26
4	4	0.80	6.11	20.3	63.0	98	13.8	1.62	2.36
5	3	0.77	5.66	25.7	88.0	90	9.5	1.72	2.42
6	4	0.75	6.34	17.6	79.5	100	10.7	1.71	2.43
7	3	0.84	4.58	19.7	92.5	98	9.3	1.84	2.42
10	5	0.71	4.79	30.2	95.5	92	6.7	1.84	2.40
12	3	0.72	2.80	16.8	92.5	94	9.8	1.70	2.22
13	3	0.63	2.89	28.5	88.0	90	11.0	1.73	2.25
17	3	0.73	4.67	20.7	85.5	99	14.7	1.72	2.16
18	3	0.70	3.11		77.5	94	7.5	1.73	2.25
19	2	0.89	2.35	24.3	89.5	98	9.0	1.67	2.41
20	2	0.75	3.34	17.3	65.5	98	5.2	1.69	2.33
22	3	0.77	4.78	18.2	75.5	94	4.6	1.75	2.33
28	3	0.78	3.41	31.1	92.5	84	9.5	1.75	2.26
31	9	0.65	3.01	28.3	77.0	96	10.8	1.85	2.29
32	3	0.77	6.71	17.8	90.5	98	2.1	1.61	2.37
33	3	0.72	5.52	29.2	88.5	92	4.7	1.67	2.36
41	3	0.80	5.14	13.6	95.0	92	10.6	1.67	2.21
42	3	0.69	6.80	13.3	95.5	80	8.0	1.62	2.20
46	4	0.70	3.67	19.1	94.0	80	16.4	1.69	20.9
47	3	0.80	5.40	17.1	79.5	88	9.3	1.68	2.27
48	4	0.74	4.69	25.0	96.0	88	8.1	1.72	2.33
49	6	1.02	5.54	22.1	96.0	98	13.2	1.78	2.30
51	3	0.79	3.99	16.7	91.5	92	21.4	1.69	2.03
53	6	0.61	1.63	5.5	79.5	92	21.8	1.63	1.97
54	2	0.70	2.99	29.2	94.0	98	10.2	1.77	2.31
55	3	0.80	4.59	15.2	91.0	100	23.1	1.73	2.11
56	3	0.76	3.52	22.2	88.5	90	16.5	1.80	2.19
57	3	0.80	4.54	15.4	91.0	96	26.9	1.74	2.02
58	3	0.75	3.76	29.0	85.0	98	15.0	1.81	2.38
60	5	0.83	4.22	19.6	85.0	92	24.2	1.81	2.16
61	4	0.68	4.36	20.2	96.5	90	9.2	1.72	2.35

Table1.3.6. Parameters measured in running-ripe female cod as well as the effect parameters measured on fertilized eggs and hatched larvae from the respective females. July/August 2000. CI- condition index (gutted weight/length^3 x100). HSI - hepato-somatic index (liver weight/fish weight x 100). GSI - gonado-somatic index (gonad weight/ fish weight x 100).

Female no.	length (cm)	maturity	CI	HSI	GSI	larvae hatched (%)	survival after hatch 8 days (%)	viable hatch (%)	malformations (%)
1	48	6	0.76	4.1	26.8	70.2	57.6	69.2	30.8
2	49	6	0.72	6.5	25.3	0.0	0.0	0.0	0.0
3	38	6	0.77	3.7	4.5	59.6	5.7	83.3	16.7
4	58	6	0.76	6.9	57.9	52.5	31.4	53.3	46.7
5	46	6	0.70	5.2	23.4	80.2	31.6	69.2	30.8
6	47	6	0.84	7.4	37.0	0.0	0.0	0.0	0.0
7	36	6	0.81	6.5	22.1	0.0	0.0	0.0	0.0
8	43	6	0.73	5.0	21.1	14.3	22.9	100.0	0.0
13	37	6	0.66	11.9	7.7	66.5	56.9	83.9	16.1
14	59	6	0.83	6.3	41.2	8.8	70.0	95.2	4.8
15	45	6	0.80	6.6	14.7	15.7	7.4	50.0	50.0
16	55	6	0.74	5.9	8.8	0.0	0.0	0.0	0.0
17	104	6	0.67	5.9	31.7	0.0	0.0	0.0	0.0
18	45	6	0.71	5.8	12.2	56.2	47.1	26.5	73.5
19	48	6	0.76	10.0	16.5	5.4	55.9	41.2	58.8
20	45	6	0.74	5.3	15.6	0.0	0.0	0.0	0.0
21	82	6	0.60	6.4	23.5	90.4	94.8	97.9	2.1
22	41	6	0.72	6.9	18.1	29.0	64.7	76.0	24.0
23	43	6	0.81	5.4	18.8	0.0	0.0	0.0	0.0
25	40	6	0.86	5.6	18.6	85.1	60.1	68.2	31.8
26	48	6	0.78	6.4	22.3	0.0	0.0		
47	35	5	0.70	6.9	22.4	0.0	0.0		
729	59	4	0.81	8.2	22.3	0.0	0.0		
730	45	7	0.70	4.1	26.0	0.0	0.0		
1001	50	7	0.72	8.2	22.2	0.0	0.0		

Table 1.3.7. Arithmetic means (± S.D.) and ranges of organochlorine content (mg/ kg lipid) in the ovaries of female cod caught in the Bornholm Basin in July/August 1999 and 2000 and, for comparison, in 1996 (Petersen et al. 1997) and in male cod (liver) caught in the Bornholm Basin in July 2000.

	Female cod 1996	
n = 28	Mean	Range
Sum PCBs	0.77 ± 1.02	(0.13 - 5.29)
Sum DDTs	0.92 ± 1.11	(0.14 - 5.43)
p.p'-DDE	0.75 ± 0.92	(0.12 - 4.42)
dieldrin	0.021 ± 0.013	(0.044-0.060)

	Female cod 1999	
n = 32	Mean	Range
Sum PCBs	1.32 ± 0.80	(0.40 - 3.98)
Sum DDTs	1.34 ± 0.94	(0.31 - 3.95)
p.p'-DDE	1.06 ± 0.79	(0.26 - 3.28)
dieldrin	0.039 ± 0.023	(0.011 - 0.12)

	Female cod 2000	
n = 27	Mean	Range
Sum PCBs	1.44 ± 1.53	(0.43 - 8.20)
Sum DDTs	1.41 ± 1.35	(0.25 - 7.15)
p.p'-DDE	1.03 ±1.16	(0.16 - 6.11)
dieldrin	0.052 ± 0.022	(0.013 - 0.096)

	Male cod 2000 (liver)	
N=11	Mean	Range
Σ-PCBs	2.08 ± 0.79	(0.85 – 3.30)
Σ –DDTs	2.30 ± 0.81	(1.22 – 3.56)
p.p´-DDE	1.44 ± 0.64	(0.60 – 2.43)
dieldrin	0.033 ± 0.013	(0.016 – 0.047)

	Male cod 2000 (testis)	
N=11	Mean	Range
Σ-PCBs	0.277 ± 0.09	(0.173 – 0.353
Σ –DDTs	0.248 ± 0.09	(0.155 – 0.345)
p.p´-DDE	0.177 ± 0.06	(0.115 – 0.24)
dieldrin	0.008 ± 0.004	(0.003 – 0.012

Table 1.3.8. Lengths, morphometric indices, and contaminant concentrations in male cod livers or testis from the Bornholm Basin in 2000.

Fish no.	Length (cm)	Maturity	CI	HSI	GSI	Sum PCBs (µg/kg lipid)	Sum DDTs (µg/kg lipid)	pp-DDE (µg/kg lipid)	dieldrin (µg/kg lipid)
698	55	7	0.724	6.6	18.9	2633	3013	2033	20
699	55	6	0.655	4.6	13.1	2550	3025	1992	21
700	38	6	0.793	4.3	10.2	846	1219	599	24
701	40	7	0.789	2.2	7.4	1849	1707	1077	16
702	41	6	0.885	3.6	8.9	1171	1541	943	21
704	49	6	0.680	4.8	10.7	3195	3559	2428	47
709	33	6	0.768	3.6	9.2	2261	2202	1247	43
712	45	6	0.697	4.1	10.6	1719	1834	1002	46
713	54	8	0.676	4.6	3.5	3304	3480	2382	45
714	49	7	0.629	6.6	15.6	1763	1992	1152	47
715	45	6	0.647	5.6	16.3	1590	1747	971	29
means	**45**		**0.73**	**4.3**	**10.8**	**2080**	**2302**	**1439**	**33**
Stand. dev.	**8**		**0.07**	**1.5**	**4.1**	**786**	**821**	**643**	**13**
402	50	6	0.648	4.7	4.5	323	345	240	7.4
403	38	6	0.702	1.7	4.4	349	243	183	6.4
404	47	6	0.718	4.0	5.0	353	328	231	11
405	38	6	0.829	3.8	4.2	178	170	115	12
406						180	155	119	2.7
Mean	**43**		**0.72**	**3.6**	**4.5**	**277**	**248**	**177.4**	**8.0**
Stand. Dev.	**6**		**0.08**	**1.3**	**0.3**	**90**	**87**	**59.7**	**3.9**

Table 1.4.1. Characteristics of established Danish and Finish data series used for extended data analyses.

Denmark	Finland
Ca. 25.000	Ca. 25.000
1968, 1969, 1984-2000	1974-1995
Length, gutted weight	Length, whole weight
Mainly 25, some in 26 and 28	28-32
Commercial fishing vessels, harbour samples	Commercial fishing vessels

Table 1.4.2. Results and significance levels for the isometry tests of cod fecundity– weight relationships. Each data set includes information about sampling time and size, female length range and median length, as well as the linear regression equation for fecundity versus body weight, the corresponding explained variance (r^2), the intercept (y_0) and the probability (p_y) that the intercept differs from zero. Regression statistics for the fecundity – weight residuals versus fish length as well as for the log transformed fecundity - weight relationships are presented in addition.

Year	Sampling months	Ovaries n	Length range (cm)	Median length (cm)	Fecundity - total weight relationships		Intercepts		Slope residuals versus length		Slope log $_{fecundity}$ versus log $_{weight}$	
						r^2	y_0	p_y	$ß_e$	p_e	$ß_w$	p_w
1987	March	64	32 / 104	56	F = 584.6*W+105944	0.76	105943	> 0.3	0.09	> 0.4	1.06	> 0.4
1988	March - May	115	27 / 76	45	F = 617.6*W-14111	0.72	- 14110	> 0.7	- 0.03	> 0.7	0.97	> 0.6
1989	April	65	37 / 62	48	F = 799.5*W-206819	0.75	- 206819	> 0.02	0.11	> 0.3	1.19	> 0.04
1990	March - April	104	35 / 68	58	F = 754.8*W-11815	0.85	- 11815	> 0.9	0.02	> 0.8	1.04	> 0.2
1991	March	77	38 / 87	51	F = 630.4*W-56807	0.74	- 56807	> 0.5	0.12	> 0.2	1.24	> 0.001
1992	March	43	41 / 98	58	F = 697.9*W-75182	0.96	- 75182	> 0.4	- 0.04	> 0.8	1.04	> 0.3
1996	April / May / July	91	36 / 84	57	F = 846.3*W+3515	0.8	35135	> 0.8	0.02	> 0.8	1.02	> 0.7
1998	March / April	40	35 / 91	51	F = 616.5*W+171600	0.73	171641	> 0.3	0.02	> 0.5	1.04	> 0.5
1999	April - July	65	26 / 126	48	F = 775.1*W+42761	0.98	42761	> 0.25	0.10	> 0.4	1.05	> 0.2
2000	March - May	94	28 / 108	48	F = 739.3*W+90356	0.84	90356	> 0.3	- 0.01	> 0.8	0.98	> 0.6

Note: $ß_e$ and p_e: Slope and respective significance level of the slope; $ß_w$ and p_w: Slope and probability level for the slope to differ from one.

Table 1.4.3. Sampling dates, sample sizes as well as length range and median length of female cod sampled in ICES Sub-division 25 in 2000 for investigations of atresia.

Sampling dates	Ovaries n	Length range min/max (cm)	Median length (cm)
April, 21st – 26th	75	21 / 73	43
May, 25th – 28th	74	26 / 77	46
July, 06th – 09th	104	31 / 59	45
August, 03rd - 05th	58	37 / 104	45

Table 1.4.4. Relative proportion of female cod with alpha atretic oocytes (P_a) per length category and maturity stage with corresponding sample size (n).

	Maturity stage															
Length	**I**		**II**		**III**		**IV**		**V**		**VI**		**VII**		**VIII**	
(cm)	n	P_a	n	P_a	n	P_a	n	P_a	n	P_a	n	P_a	n	P_a	n	P_a
<= 30	5	0	4	0	2	0	1	0	0		0		0		4	1.00
31 - 40	6	0	11	0.09	11	0.09	2	0.50	10	0.10	11	0.36	10	0.70	1	1.00
41 - 50	2	0	2	0	19	0.16	42	0.21	35	0.23	27	0.33	35	0.37	1	1.00
51 - 60	0		0		4	0	17	0.24	10	0.40	4	0.50	8	0.38	1	1.00
> 60	0		0		0		2	0	8	0.50	5	0.40	7	0.71	0	

Table 1.4.5a. ANCOVA of relative fecundity vs. principal components (output from GLM Procedure in SAS).

Dependent Variable: RELFEC

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	1379302.23	459767.41	7.32	0.0001
Error	139	8729658.79	62803.30		
Corrected Total	142	10108961.02			

R-Square	Coeff Var	Root MSE	RELFEC Mean
0.136444	33.05181	250.6059	758.2212

Source	DF	Type III SS	Mean Square	F Value	Pr > F
N7	1	595008.1275	595008.1275	9.47	0.0025
N9	1	434353.3773	434353.3773	6.92	0.0095
N14	1	232026.9358	232026.9358	3.69	0.0566

Tab. 1.4.5b. ANCOVA of relative fecundity vs. principal components (output from GLM Procedure in SAS).

Class	Levels	Values
y	4	87 96 98 99

Number of observations 143

Dependent Variable: RELFEC

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	15	3523501.76	234900.12	4.53	<.0001
Error	127	6585459.25	51854.01		
Corrected Total	142	10108961.02			

R-Square	Coeff Var	Root MSE	RELFEC Mean
0.348552	30.03276	227.7148	758.2212

Source	DF	Type III SS	Mean Square	F Value	Pr > F
N7	1	631481.121	631481.121	12.18	0.0007
N9	1	535230.110	535230.110	10.32	0.0017
N14	1	609209.789	609209.789	11.75	0.0008
N7*y	3	533238.732	177746.244	3.43	0.0192
N9*y	3	606230.300	202076.767	3.90	0.0106
N14*y	3	419611.511	139870.504	2.70	0.0487
y	3	1214195.205	404731.735	7.81	<.0001

Table 1.4 .6. Age composition of sprat (%) in the Gulf of Finland in 1986-97. Abundant year-classes are in bold.

Year	No. of fish aged	Proportion (%) of fish at age										
		0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10+**
1986	948	**0.0**	8.0	**50.6**	6.0	**24.8**	2.8	8.2	1.3	0.0	0.0	2.3
1987	1093	0.0	**24.0**	3.6	**35.8**	6.8	**25.0**	1.0	6.9	0.7	0.6	2.3
1988	200*	**0.0**	0.5	**36.7**	5.7	**29.1**	4.6	**17.1**	1.0	3.5	0.1	1.9
1989	792	**0.1**	**31.4**	2.8	**28.5**	2.1	**18.0**	2.6	**9.4**	0.4	3.2	1.5
1990	1672	0.0	**26.6**	**32.5**	1.2	**19.0**	1.2	**11.1**	1.4	**5.5**	0.2	1.3
1991	750	**1.4**	6.1	**26.1**	**31.7**	1.0	**16.7**	1.3	**9.9**	0.6	**3.0**	1.4
1992	1211	0.5	**37.8**	10.1	**19.2**	**13.7**	0.7	**9.7**	0.3	**5.0**	0.2	**2.7**
1993	200*	0.0	3.7	**50.7**	7.3	**13.2**	**8.7**	1.2	**7.4**	0.7	**4.0**	2.6
1994	3278	**0.7**	1.6	14.8	**48.2**	8.7	**9.4**	**6.3**	2.5	**3.0**	1.2	**3.7**
1995	2835	0.5	**28.5**	4.8	23.5	**16.6**	5.9	**6.3**	**4.3**	2.0	**1.9**	5.7
1996	4635	0.6	5.1	**51.8**	13.0	13.9	**6.5**	5.1	**2.0**	**0.9**	0.4	**0.9**
1997	4476	0.8	5.5	21.1	**57.9**	6.4	5.3	**1.9**	0.8	**0.1**	**0.1**	0.1

Table 1.4.7. Von Bertalanffy growth parameters of sprat in the Gulf of Finland in 1986-97.

Values calculated	Asymptotic length, cm		Coefficient *K* for length		Asymptotic weight, g		Coefficient *K* for weight	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Years	13.7-14.6	14.1	0.25-0.68	0.43	12.2-16.8	15.1	0.39-0.85	0.48
Year-classes	12.8-15.5	14.1	0.21-0.66	0.49	11.5-17.0	15.0	0.35-1.51	0.69

Table 1.4.8. Average absolute (ABF) batch fecundity and sample size of sprat female by length group monthly in April, June 1992-95, March and May 1999 and June 2000.

	March		April					
L (cm)	1999		1992		1993		1994	
10.0	815.5	(2)					598	(1)
10.5	1531	(1)	1149	(1)	901	(1)	654±46	(4)
11.0	1151±86	(12)	948	(2)	1035±223	(4)		
11.5	1254±136	(9)	1366	(2)	995±85	(4)	1178±154	(5)
12.0	1419±114	(10)	1638	(1)	1474±323	(3)	1096	(2)
12.5	1449±189	(4)	878	(1)	1163±278	(4)	1364	(1)
13.0	1391	(1)	1486±121	(7)	1601±213	(8)	1713	(2)
13.5	1627	(1)			1933±559	(3)		
14.0					2066±303	(5)		
14.5								
15.0								
15.5								
n:		(40)		(14)		(32)		(15)

	May							
L (cm)	1992		1994		1995		1999	
10.0							804±81	(6)
10.5	1572	(1)	1233	(2)	1770	(1)	724±84	(10)
11.0	1514±345	(6)	1052±115	(3)	1408±98	(8)	1147±97	(13)
11.5	1658±139	(20)	1266±107	(9)	1356±53	(31)	1307±94	(12)
12.0	1636±81	(40)	1521±151	(10)	1505±53	(40)	1428±121	(13)
12.5	1728±70	(41)	1416	(2)	1502±87	(28)	1608±127	(4)
13.0	1795±82	(35)			1621±67	(19)	1833±150	(5)
13.5	1885±127	(19)			1285±150	(5)		
14.0	2595±199	(12)			1670±144	(8)		
14.5	2031±88	(3)			2939	(1)		
15.0								
15.5					3028	(1)		
n:		(177)		(26)		(141)		(63)

	June							
L (cm)	1992		1994		1995		2000	
10.0								
10.5							706	(1)
11.0			1061±109	(3)	1010	(1)	1510±89	(17)
11.5	1975±221	(5)	1022±69	(5)	1497±84	(3)	1494±65	(40)
12.0	1818±132	(8)	1435±102	(11)	1223±324	(3)	1852±76	(34)
12.5	2220±136	(12)	1717±200	(5)	1730±362	(4)	2046±96	(16)
13.0	2604±199	(8)	1412±301	(3)	1900±204	(4)	1873±135	(9)
13.5	1991	(2)	2061±137	(3)	2068±81	(3)	2146	(2)
14.0	2265	(1)	1732	(1)				
14.5			1985	(1)				
15.0								
15.5								
n:		(36)		(32)		(18)		(119)

Table 1.4.9. Average absolute (ABF) batch fecundity and sample size of sprat female by length groups in April-June.

L (cm)	April		May		June	
10.0	598	(1)				
10.5	777±89	(6)	1452±147	(4)		
11.0	1005±170	(6)	1383±130	(17)	1048±78	(4)
11.5	1146±86	(11)	1443±59	(60)	1498±147	(13)
12.0	1375±199	(6)	1566±46	(90)	1546±91	(22)
12.5	1149±187	(6)	1631±55	(71)	2007±121	(21)
13.0	1567±113	(17)	1734±59	(54)	2178±180	(15)
13.5	1933±559	(3)	1761±115	(24)	2046±83	(8)
14.0	2066±303	(5)	2225±166	(20)	1999	(2)
14.5			2259±235	(4)	1985	(1)
15.0						
15.5			3028	(1)		
n:		(61)		(344)		(86)

Table 1.4.10. Average relative (RBF) batch fecundity and sample size of sprat female by length groups in different years.

	April-June		April-June		May. June		March. May		June	
L (cm)	1992		1994		1995		1999		2000	
10.0			598	(1)			808±81	(8)		
10.5	1361	(2)	847±132	(6)	1770	(1)	847±122	(11)	706	(1)
11.0	1373±278	(8)	1057±71	(6)	1363±97	(9)	1186±63	(25)	1510±89	(17)
11.5	1695±113	(27)	1178±68	(19)	1369±49	(34)	1286±77	(21)	1494±66	(40)
12.0	1667±70	(49)	1443±87	(23)	1485±54	(43)	1424±83	(23)	1852±77	(34)
12.5	1822±69	(54)	1598±170	(8)	1531±87	(32)	1529±111	(8)	2046±97	(16)
13.0	1881±82	(50)	1532±207	(5)	1669±67	(23)	1759±143	(6)	1873±135	(9)
13.5	1896±117	(21)	2061±137	(3)	1579±171	(8)	1627	(1)	2146	(2)
14.0	2570±185	(13)	1732	(1)	1670±144	(8)				
14.5	2032±88	(3)	1985	(1)	2939	(1)				
15.0										
15.5					3028	(1)				
n:		(227)		(73)		(160)		(103)		(119)

Table1.4.11. Average gutted weight of sprat female by length groups (material used for account of batch fecundity).

	1992			1993	1994			1995		1999		2000
L (cm)	April	May	June	April	April	May	June	May	June	March	May	June
10.0					6.4					5.5	5.8±0.2	
10.5	7.7	7.5		6.5	6.6±0.2	7.2		7.3			6.2±0.2	6.6
11.0	9.3	8.8±0.3		7.4±0.3		8.0	9.1	7.9±0.2	8.0	7.3±0.2	7.1±0.1	7.7±0.2
11.5	10.9	9.5±0.2	9.5±0.3	8.4±0.2	8.8±0.3	8.1±0.3	8.8±0.6	8.6±0.1	8.5	7.8±0.2	7.8±0.2	8.6±0.1
12.0	11.0	10.8±0.2	11.1±0.2	11.1	9.3	10.0±0.4	10.4±0.3	9.5±0.1	9.6	8.7±0.2	8.9±0.2	9.3±0.1
12.5	11.7	12.0±0.2	11.9±0.3	10.6±0.3	9.4	11.4	11.8±0.4	10.5±0.2	10.9±0.5	10.3±0.4	9.5±0.5	10.2±0.2
13.0	12.6±0.3	13.1±0.2	12.9±0.4	12.0±0.2	11.5		12.4	11.9±0.3	11.2±0.5	13.0	10.7±0.5	11.6±0.2
13.5		14.2±0.2	13.1	14.7±0.3			14.8	11.8±0.7	12.4	12.0		12.7±0.1
14.0		15.1±0.2	16.4	13.8±0.2			16.0	14.1±0.4		12.0		
14.5		15.9					15.7	17.4				
15.0												
15.5								19.7				
In sample:	11.4±0.5	12.0±0.2	11.8±0.3	11.1±0.4	8.5±0.4	9.0±0.3	11.2±0.4	10.2±0.2	10.4±0.4	8.3±0.2	7.9±0.2	9.1±0.1

Table 1.4.12. Average relative (RBF) batch fecundity of sprat female by length groups in April-June 1992, March and May 1999, June 2000.

	March	April			May				June			
L (cm)	1999	1992	1993	1994	1992	1994	1995	1999	1992	1994	1995	2000
10.0	154.0			94.0				130.5±14.9				
10.5	191.0	149.0	139.0	97.8±11.0	210.0	173.5	242.0	128.3±12.1				107.0
11.0	158.5±10.2	101.5	140.0±29.5		182.6±32.5	131.7	180.0±11.7	160.5±13.9		116.0	126.0	195.3±10.7
11.5	154.5±15.8	127.5	120.5±11.1	134.8±18.6	174.6±13.8	163.1±22.3	159.2±7.7	167.9±11.6	207.4±18.4	117.6±9.3	178.0	174.7±7.2
12.0	162.4±12.2	149.5	134.7	117.5	151.3±7.1	152.6±14.2	157.9±5.5	162.3±12.7	165.4±12.9	137.6±9.6	126.0	202.1±9.2
12.5	141.2	75.0	95.7±12.8	145.0	146.4±6.4	126.0	142.4±7.1	172.2±18.9	187.7±10.9	144.4±13.9	162.0±38.1	197.5±11.0
13.0	107.0	117.7±8.5	134.0±18.5	149.0	137.0±6.9		139.1 ±6.2	163.2±17.4	202.6±15.7	149.0	169.0±13.2	160.4±10.6
13.5	127.0		130.0		134.6±9.7		109.0±10.5		152.0	139.0	167.3	168.7
14.0			151.2±23.5		173.4±14.1		119.1±10.8		138.0	108.0		
14.5					128.0		169.0			126.0		
15.0												
15.5							154.0					
In sum:	155.3±6.3	118.2±7.8	130.8±8.1	122.5±9.4	150.4±3.4	153.4±10.2	150.5±3.3	158.3±5.5	185.4±6.8	133.4±4.6	159.1±10.5	186.8±1.0

Table 1.4.13. Average relative (RBF) batch fecundity of sprat female by weight groups (gutted weight) in April, May, June 1992-95, March, May 1999 and June 2000 with sample sizes.

	March	April			May				June			
Weight (g)	1999	1992	1993	1994	1992	1994	1995	1999	1992	1994	1995	2000
4.5								147.0				
5.0								149.0				
5.5								113.2±16.5				195.2
6.0	101.0			107.5		302.0		118.3±15.9				254.2
6.5	121.7		152.0	90±11.0		207.0	250.5	138.5±14.9				154.7±24.2
7.0	162.9±9.7					196.5	209.5	166.6±14.4			195.0	174.1
7.5	171.0±17.2	149.0	129.5±28.3		210.0	140.0	200.5±12.1	140.1±12.7		142.0		183.1±12.5
8.0	156.1±12.9		121.0	148.0	164.2±37.1	133.3±10.3	167.1±9.3	164.4±13.0	190.0	106.0	126.0	193.4±11.5
8.5	231.0			133.0	178.1±21.2	130.8±8.1	145.7±10.2	157.8±19.9		109.5	194.0	188.8±13.0
9.0	126.5	65.0	146.5	111.5	182.8±11.5	131.0±29.0	148.8±7.2	148.2±14.8	157.0	138.3±21.4	80.0	190.9±11.5
9.5	131.0	138.0		134.5	144.5±20.4	181.0	143.0±8.7	129.3	227.0	145.0	147.7±20.8	203.2±10.0
10.0	157.5		86.0		173.9±15.2	175.5	150.3±4.4	130.2±24.1	198.3±38.7	125.3±14.5	226.0	191.7±11.2
10.5		144.0	130.0	128.0	156.9±12.4	125.0	144.5±8.8	192.0	184.8±13.8	138.8±19.5	125.7±26.5	162.6±29.0
11.0	113.0	128.0	155.3±37.5		160.9±18.0	179.0	154.7±14.8	117.0	190.8±21.1	131.5	189.0	163.0±19.7
11.5		107.3±21.5	75.0±11.0		136.9±8.2	73.0	145.8±16.6		186.7±25.0	115.7±12.3	178.0	152.5±19.3
12.0	127.0	100.0	151.5	170.0	153.7±11.1		133.5±19.0	156.0	165.3±18.0	173.5	119.0	173.6±8.9
12.5		100.0	129±28.6		136.9±10.6		149.0	116.0	196.2±22.6	157.0	170.3±10.1	
13.0	107.0	121.5	201.0		135.1±10.5	145.0	124.8±11.8		184.8±30.3	139.0		180.4
13.5		134.0	107.0		154.9±11.2		116.0		196.0			
14.0			58.0		125.6±10.2		131.6±8.3		176.5	134.0		
14.5					135.6±18.0		69.0			135.0		

Table 1.4.13. (continued)

	March	April			May				June			
Weight (g)	1999	1992	1993	1994	1992	1994	1995	1999	1992	1994	1995	2000
15.0			157.3±9.1		168.3±20.4							
15.5					142.3±31.5					137.0		
16.0					114.0±23.1		110.0		138.0	108.0		
16.5					128.0							
17.0					123.0		169.0					
19.5							154.0					
In sum:	150.3±6.7	118.2±7.8	130.8±8.1	122.5±9.4	150.4±3.4	153.4±10.2	150.5±3.3	146.2±5.1	185.4±6.8	133.4±4.6	159.1±10.4	186.8±4.4
	(39)	(14)	(32)	(15)	(177)	(26)	(141)	(73)	(36)	(32)	(18)	(119)

Table 1.4.14. a. Average relative (RBF) batch fecundity and sample size of sprat female by groups in April and June 1992-95.

L (cm)	April		May		June	
10.0	94.0	(1)				
10.5	113.2±12.0	(6)	199.8±21.4	(4)		
11.0	127.0±22.4	(6)	171.7±12.3	(17)	118.5±5.2	(4)
11.5	128.3±9.5	(11)	164.9±6.9	(60)	161.1±14.1	(13)
12.0	131.3±17.9	(6)	152.8±4.5	(90)	146.1±8.1	(22)
12.5	103.0±13.8	(6)	145.0±4.8	(71)	172.5±10.2	(21)
13.0	129.1±9.6	(17)	137.7±5.0	(54)	182.9±10.6	(15)
13.5	130.0	(3)	129.3±8.1	(24)	152.9±7.2	(8)
14.0	151.2±23.5	(5)	151.7±11.1	(20)	123.0	(2)
14.5			138.3±10.4	(4)	126.0	(1)
15.0						
15.5			154.0	(1)		
In sum:	126.7±5.2	(61)	150.8±2.4	(344)	160.6±4.7	(86)

Table 1.4.14. b. Average relative (RBF) batch fecundity and sample size of sprat female by weight groups in April and June 1992-95.

Weight (g)	April		May		June	
6.0	107.5	(2)	302.0	(1)		
6.5	114.8±16.9	(5)	236±43.2	(3)		
7.0			203±25.8	(4)	195.0	(1)
7.5	133.4±22.3	(5)	192.0±13.0	(6)	142.0	(1)
8.0	134.5±26.2	(4)	161.2±8.7	(25)	132.0±20.0	(4)
8.5	133.0	(2)	150.6±8.2	(28)	137.7±28.2	(3)
9.0	116.2±20.6	(5)	157.5±6.8	(29)	130.4±17.6	(5)
9.5	135.7±13.0	(3)	146.3±8.5	(27)	160.0±16.8	(6)
10.0	86.0	(2)	161.2±6.9	(35)	177.9±21.0	(8)
10.5	134±5.0	(3)	150.0±7.4	(26)	154.7±12.5	(12)
11.0	144.4±22.6	(5)	159.9±12.1	(19)	175.8±16.0	(8)
11.5	91.2±12.2	(6)	137.5±7.9	(26)	155.0±17.5	(7)
12.0	143.3±15.4	(4)	148.2±9.5	(22)	161.0±13.1	(7)
12.5	121.8±21.5	(4)	137.6±10.0	(19)	180.6±12.4	(10)
13.0	161.3±27.5	(4)	133.5±8.0	(19)	175.6±25.2	(5)
13.5	116±10.7	(3)	148.4±10.2	(12)	196.0	(1)
14.0	58.0	(1)	127.3±7.6	(18)	162.3±17.1	(3)
14.5			128.2±17.5	(9)	135.0	(1)
15.0	157.3±9.1	(3)	168.3±20.4	(6)		
15.5			142.3±31.5	(3)	137.0	(2)
16.0			113.0±16.4	(4)	123.0	(2)
16.5			128.0	(1)		
17.0			146.0	(2)		
19.5			154.0	(1)		
In sum:	126.7±5.2	(61)	150.8±2.4	(344)	160.6±4.7	(86)

Table 1.4.15. a. Average relative (RBF) batch fecundity and sample size of sprat female by length groups in different years.

L (cm)	1992		1994		1995		1999		2000	
10.0			94.0	(1)			136.4±14.6	(8)		
10.5	179.5	(2)	123.0±19.4	(6)	242.0	(1)	135.2±13.3	(11)	107.0	(1)
11.0	150.6±25.9	(8)	123.8±7.9	(6)	173.4±11.8	(9)	162.9±8.4	(25)	195.3±10.7	(17)
11.5	177.0±11.3	(27)	143.7±12.3	(19)	160.8±7.2	(34)	162.2±9.4	(21)	174.7±7.2	(40)
12.0	153.6±6.2	(49)	142.4±8.2	(23)	155.7±5.6	(43)	162.3±8.7	(23)	202.1±9.2	(34)
12.5	154.2±6.1	(54)	139.9±13.4	(8)	144.9±7.6	(32)	156.7±13.8	(8)	197.5±11.0	(16)
13.0	145.8±6.6	(50)	149.0±9.1	(5)	144.3±6.0	(23)	162.3±17.7	(6)	160.4±10.6	(9)
13.5	136.2±9.0	(21)	139.0	(3)	130.9±12.7	(8)	127.0		168.7	(2)
14.0	170.7±13.3	(13)	108.0	(1)	119.1±10.7	(8)				
14.5	128.0	(3)	126.0	(1)	169.0	(1)				
15.0										
15.5					154.0	(1)				
In sum:	154.0±3.2	(227)	138.3±4.7	(73)	151.5±3.1	(160)	155.3±6.3	(103)	186.8±1.0	(119)

Table 1.4.15. b. Average relative (RBF) batch fecundity and sample size of sprat female by weight groups in different years.

Weight (g)	1992		1994		1995		1999		2000	
4.5							147.0	(1)		
5.0							149.0	(1)		
5.5							113.2±16.5	(4)	195.2	(1)
6.0			172.3±65.3	(3)			116.0±13.6	(7)	254.2	(1)
6.5			119.3±30.3	(4)	250.5	(2)	125.0±10.2	(11)	154.7±24.2	(3)
7.0			196.5	(2)	204.7±19.4	(3)	167.8±10.1	(21)	174.1	(1)
7.5	179.5	(2)	141.0	(2)	200.5±12.1	(4)	164.0±9.9	(16)	183.1±12.5	(12)
8.0	169.4±29.2	(5)	130.1±12.8	(8)	164.8±9.1	(18)	156.5±11.1	(19)	193.4±11.5	(19)
8.5	178.1±21.1	(7)	127.0±5.6	(10)	148.7±10.0	(16)	170.0±20.1	(6)	188.±13.0	(21)
9.0	169.7±14.2	(11)	128.9±14.0	(8)	145.0±7.8	(18)	142.8±12.0	(8)	190.9±11.5	(19)
9.5	152.1±18.1	(10)	153.5±16.8	(6)	143.7±7.8	(20)	147.2±24.8	(5)	203.2±10.0	(12)
10.0	178.2±13.9	(17)	145.4±19.9	(5)	157.5±6.4	(21)	139.3±17.6	(9)	191.7±11.2	(12)
10.5	163.6±9.5	(19)	134.7±12.6	(6)	140.7±8.5	15	192.0	(1)	162.6±29.0	(6)
11.0	165.3±13.1	(19)	147.3±16.6	(3)	159.6±13.4	(7)	105.0	(2)	163.0±19.7	(4)
11.5	139.6±8.4	(22)	105.0±13.7	(4)	149.0±15.2	(10)			152.5±19.3	(4)
12.0	153.4±9.4	(21)	172.3±14.2	(3)	131.4±16.2	(7)	113.3	(3)	173.6±8.9	(3)
12.5	147.8±10.5	(24)	157.0	(2)	165.0±8.9	(4)	116.0	(1)		
13.0	143.7±10.3	(20)	142.0	(2)	124.8±11.8	(4)	107.0	(1)	180.4	(1)
13.5	156.6±10.1	(12)			116.0	(2)				
14.0	132.4±10.1	(15)	134.0	(1)	131.6±8.3	(5)				
14.5	135.6±18.0	(8)	135.0	(1)	69.0	(1)				
15.0	168.3±20.4	(6)								
15.5	142.3±31.5	(3)	137.0	(2)						
16.0	120.0±17.4	(4)	108.0	(1)	110.0	(1)				
16.5	128.0	(1)								
17.0	123.0	(1)			169.0	(1)				
19.5					154.0	(1)				
In sum:	154.0±3.2	(227)	138.3±4.7	(73)	151.5±3.1	(160)	155.3±6.3	(103)	186.8±1.0	(119)

Table 1.5.1. Coefficients of determination and corresponding probability values for relation-ships of potential egg production (PEP) with constant sex ratio, maturity ogive, relative fecundity and mean weight at age versus realised daily (RDEP) and seasonal egg production (RSEP). In addition reference relationships of PEP (ORF) versus RDEP and RSEP are given.

PEP		RDEP	RSEP
Constant sex ratio	r^2	0.67	0.86
	p	< 0.001	< 0.01
Constant maturity ogive	r^2	0.38	0.47
	p	< 0.05	*0.13*
Constant relative fecundity	r^2	0.55	0.81
	p	< 0.005	< 0.05
Constant weight at age	r^2	0.52	0.87
	p	<0.005	<0.01
Observed data	r^2	0.72	0.91
	p	< 0.001	< 0.005

Table 1.5.2. Linear regression between SSB and realised egg production of sprat. Realised egg production = average daily production of stage I eggs per day (n*day-1) during the main spawning season derived from ichthyoplankton surveys. The table presents parameter estimates and their significance levels, r^2-values and Durbin Watson (DW) statistics indicating serial correlation in the residuals if significant (* = significant at 5% level). No reliable egg production rates from ichthyoplankton surveys were available for 1992.

Independent variable	Sub-division	Time series	Parameter	Parameter estimates	p	r^2	DW statistics
sprat SSB	26	1977-96 without 1992	Slope	$1.3710 \cdot 10^{-4}$	0.002	0.44	2.16
			Intercept	12.334	0.201		
sprat SSB	28	1977-96 without 1992	Slope	$1.9014 \cdot 10^{-4}$	0.004	0.39	1.36
			Intercept	5.9692	0.492		

Tab. 2.1.1. Bongo/Babybongo sampling during the reporting period. Number of hauls performed in the different basins. Mesh sizes applied: 500µm, 335µm, 150µm and 50.µm for Bongo net; 500 µm for IKS-80.

		Bornholm Basin		Stolpe Trench		Gdansk Deep		Gotland Basin	
Date	Cruise	Bongo	IKS-80	Bongo	IKS-80	Bongo	IKS-80	Bongo	IKS-80
March	Atlantniro	0	0	0	0	0	18	0	0
14.-17.4.99	Al 141	45	0	4	0	11	11	24	24
24.-26.04.99	Al 141	36	0	0	0	0	0	0	0
8.-20.5.99	Atlantniro	0	0	0	0	0	20	0	10
18.-21.5.99	Al 143	44	4	10	5	17	17	38	38
22.-25.05.99	Al 143	42	0	0	0	0	0	0	0
3.-5.6.99	Al 143	33	0	0	0	0	0	0	0
4.-6.6.99	Wh 206	11	0	0	0	0	0	0	0
28.6.-6.7.99	Al 145	58	0	5	2	18	18	0	0
18.-20.6.99	Karmena	0	0	0	0	0	0	0	53
25.-29.7.99	Al 147	59	4	10	4	17	17	41	41
5.-10.8.99	Al 147	54	0	8	0	0	0	0	0
24.8.-1.9.99	Al 148	42	4	10	4	16	16	0	4

Table 2.1.2. Ratio of cod egg abundance in May and mean cod egg abundance in April - June (according to Grauman, 1980)

Area	April	May	June	mean	n May / n mean
Bornholm Basin	60	67	63	63,3	1,06
Gdansk Deep	10	23	25	19,3	1,19
Sothern Gotland Basin	18	37	13	22,67	**1,63**

Tab. 2.1.3. Sampling intervals, age difference, daily production and instantaneous mortality coefficients (z) of successive stages of Baltic cod eggs in July 1996 (*: calculated for the mean ambient temperature of 3.85 °C, **: adjusted for dt age).

Developmental stages	Series of samples	dt samples (days)	dt age (days)		Production observed*	(n/m²/day) estimated **	z (per day)
IA/IB	1			IA:	21.128		
	2	3.23	3.06	IB:	16.701	16.867	0.074
	2			IA:	19.201		
	4	2.96	3.06	IB:	16.354	16.343	0.053
	3			IA:	19.025		
	5	2.97	3.06	IB:	14.089	14.047	0.099
						mean:	0.075
						sd:	0.023
IB/II	1			IB:	19.773		
	2	3.23	3.01	II:	4.218	4.278	0.509
	2			IB:	16.701		
	4	2.96	3.01	II:	4.135	4.134	0.464
	3			IB:	15.560		
	5	2.97	3.01	II:	3.514	3.510	0.495
						mean:	0.489
						sd:	0.023
II/III	1			II:	5.096		
	3	5.31	5.39	III:	0.981	0.980	0.306
	2			II:	4.218		
	5	5.05	5.39	III:	0.891	0.885	0.290
	3			II:	3.822		
	6	5.25	5.39	III:	0.793	0.788	0.293
						mean:	0.296
						sd:	0.008
III/IV	1			III:	1.032		
	3	5.31	5.23	IV:	0.062	0.062	0.537
	2			III:	0.983		
	5	5.05	5.23	IV:	0.076	0.075	0.491
	3			III:	0.981		
	6	5.25	5.23	IV:	0.070	0.070	0.504
						mean:	0.511
						sd:	0.024
IV/L	1			IV:	0.080		
	3	5.31	5.00	L:	0.004	0.003	0.627
	2			IV:	0.088		
	5	5.05	5.00	L:	0.006	0.006	0.544
	3			IV:	0.062		
	6	5.25	5.00	L:	0.006	0.006	0.477
						mean:	0.549
						sd:	0.075

Table 2.1.4. Abundance (n/m^2) and daily production ($n/m^2/d$) of different developmental stages inside the 80m depth contour line with and without correction for transport ($_{corr}$), as well as resulting mortaliy rates (M) for May 1988 and August 1991.

	May 1988				August 1991			
	time interval between surveys: 5.66 days;				time interval between surveys: 5.92 days;			
survey	1	2	1	2	1	2	1	2
stage	Egg IV	L 5	L 5-7	L 8	Egg IV	L 5	L 5-7	L 8
age [days] *	14.09	19.35	22.35	28.35	13.51	19.72	21.72	27.72
dt age	5.26		6.00		6.21		6.00	
n/m^2	0.98	0.21	2.43	1.50	0.66	0.52	1.97	0.33
$n/m^2/d$	0.39	0.11	0.41	0.25	0.27	0.26	0.33	0.06
M [1/d]	0.2359		0.0804		0.0078		0.2972	
M [%/d]	21.02		7.73		0.78		25.71	
$n/m^2/d_{corr}$		0.12		0.26		0.27		0.07
M $[1/d]_{corr}$	0.2226		0.0729		0.0008		0.2547	
M $[\%/d]_{corr}$	19.95		7.03		0.08		22.49	

*: at mean ambient egg incubation temperatures of 5.75 °C in May 1998 and 5.87 °C in August 1991

Tab. 2.1.5. Statistical testing of the influence of wind forcing and survey design on abundance estimate accuracy; tested variable, applied test, number of observations (n) and number of performed tests.

Tested variable	Test	n	Number of tests
Time period (i.e. wind forcing May 88 vs. Aug.91)	Wilcoxon's signed rank test for paired samples	480	1
Time interval between stations (1.5 vs. 1 h)	Wilcoxon's signed rank test for paired samples	240	2
Sequence of stations (options 1-6)	*Friedman ANOVA*	40	4
Start point of sampling (day 0 vs. day 5)	Wilcoxon's signed rank test for paired samples	20	24

Tab. 2.1.6. Cod egg abundance (n/m²) in the Gdansk Deep in 1996-1999 (May-July)

Year	cod egg abundance (n/m²)
1996	3.2
1997	2.6
1998	0.6
1999	0.8

Tab. 2.1.7. Sprat early developmental stages abundance (sp/m^2) the Gdansk Deep in 1996

Date	Egg developmental stages					Larvae
	I	II	III	IV	I-IV	
22.05-23.05						
n	55.6	22.7	19.9	1.1	99.3	8.3
%	56.0	22.8	20.1	1.1	100.0	
23.07-26.07						
n	160.6	75.1	34.7	0.8	271.2	3.0
%	59.2	27.7	12.8	0.3	100.0	
V-VII						
n	108.1	48.9	27.3	0.9	185.2	5.6
%	58.4	26.4	14.7	0.5	100.0	

Tab. 2.1.8. Sprat early developmental stages abundance (sp/m^2) in the Gdansk Deep, 1997

Date	Egg developmantal stages					Larvae
	I	II	III	IV	I-IV	
02-05.06						
n	165.5	68.7	54.8	0.9	289.9	10.6
%	57.1	23.7	18.9	0.3	100.0	
24.07-27.07						
n	71.7	60.6	27.2	1.3	160.8	2.9
%	44.6	37.7	16.9	0.8	100.0	
VI-VII						
n	118.6	64.7	41.0	1.1	225.4	6.8
%	52.6	28.7	18.2	0.5	100.0	

Tab. 2.1.9. Sprat early developmental stages in the Gdansk Deep, 1998

Date	Egg developmantal stages					Larvae
	I	II	III	IV	I-IV	
25-26.04						
n	150.8	74.8	85.2	6.0	316.8	120.3
%	47.6	23.6	26.9	1.9	100.0	
23-24.05						
n	386.2	162.9	127.6	2.1	678.8 *	18.4
%	56.9	24.0	18.8	0.3	100.0	
11-12.07						
n	256.5	125.4	83.2	4.7	469.8	10.8
%	54.6	26.7	17.7	1.0	100.0	
IV-VII						
n	264.5	121.0	98.7	4.3	488.5	49.8
%	54.1	24.8	20.2	0.9	100.0	

- - the area between 54°48′ - 55°19′N

Tab. 2.1.10. Sprat early developmental stages abundance (sp/m^2) the Gdansk Deep in 1999

Date	Egg developmental stages					Larvae
	I	II	III	IV	I-IV	
19-20.04						
n	100.2	53.4	54.4	4.7	212.7	12.9
%	47.1	25.1	25.6	2.2	100	
28-31.05						
n	337.4	142.7	82.6	3.4	566.1	32.2
%	59.6	25.2	14.6	0.6	100	
03-05.07						
n	420.6	107.1	51.8	2.3	581.8	6.9
%	72.3	18.4	8.9	0.4	100	
30-31.07						
n	3.6	2.7	2.4	0.1	8.8	0.1
%	40.2	31.0	27.3	1.5	100	
IV-VII						
n	215.5	76.5	47.8	2.6	342.4	13.0
%	62.9	22.3	14.0	0.8	100	

Tab. 2.1.11. Sprat early developmental stages abundance (sp/m^2) the Gdansk Deep in 2000

Date	Egg developmental stages					Larvae
	I	II	III	IV	I-IV	
25-31.05						
n	241.1	57.4	34.4	1.0	334.0	4.6
%	72.2	17.2	10.3	0.3	100	

Tab. 2.1.12. Cod and sprat egg abundance (n/m^2) in the Gdansk Deep, the Southern Gotland Basin and the Bornholm Basin in 1946 - 1970 (spring - summer, MIR (Poland) and AtlantNIRO (Russia) sampling

Year	Gdansk Deep		Southern Gotland Basin		Bornholm Basin	
	cod	sprat	cod	sprat	cod	sprat
1938	24	1	1	2	71	6
1946	82	100	-	-	-	-
1947	136	44	-	-	-	-
1948	139	119	-	-	-	-
1949	153	31	126 (79)	2	90	132
1951	43	95	98 (82)	60	194	58
1952	62	84	237 (148)	50	182	59
1953	28	60	141 (88)	98	99	11
1954	99	82	106 (66)	93	81	3
1955	41	160	10	-	50	4
1956	18	15	74	6	35	5
1957	11	40	31	26	47	47
1958	8	10	6	-	66	14
1959	18	79	6	54	40	32
1960	12	46	12	25	-	-
1961	10	36	11	22	14	20
1962	9	46	9	51	46	38
1963	3	60	7	40	34	30
1964	15	66	12	55	52	49
1965	8	20	11	23	25	10
1966	8	18	23	30	35	13
1967	23	44	37	52	34	59
1968	7	25	12	50	36	34
1969	22	112	22	51	70	72
1970	32	95	80	174	75	82

Tab. 2.1.13. Cod and sprat egg abundance (n/m^2) for 5-year time intervals.

Years	Cod			Sprat		
	Gdansk Deep	Southern Gotland	Bornholm basin	Gdansk Deep	Southern Gotland	Bornholm Basin
1946 - 1950	127,5	-	-	73,5	-	-
1951 - 1955	54,6	78,8	121,2	96,2	75,2	27,0
1956 - 1960	13,4	25,8	24,5	38,0	27,8	24,5
1961 - 1965	9,0	10,0	29,4	45,6	38,2	29,4
1966 - 1970	18,4	34,8	52,0	58,8	71,4	52,0

Tab. 2.1.14. Amount of pelagic fish eggs (n/100m^3) at different depth in May 1999, Gdansk Deep. 6 parallels BIOMOC sampling.

Depth, m	Cod							Mean	SD	Sprat							Mean	SD
5	0	0	0	0	0	0		**0**	**0**	10	43	30	4	9	10		**18**	**15**
10	0	0	0	0	0	0		**0**	**0**	42	18	55	18	6	32		**29**	**18**
15	0	0	0	0	0	0		**0**	**0**	212	20	150	90	36	84		**99**	**72**
20	0	0	0	0	0	0		**0**	**0**	199	223	127	153	94	302		**183**	**75**
25	0							**0**		282							**282**	
30	0	0	0	0	0	0		**0**	**0**	171	360	190	230	133	391		**246**	**106**
35	0							**0**		402							**402**	
40	0	0	0	0	0	0		**0**	**0**	344	142	115	244	291	144		**213**	**93**
45	0							**0**		156							**156**	
50	0	0	0	0	0			**0**	**0**	324	144	248	169	258			**228**	**73**
55	0	0	0	0	0			**0**	**0**	243	186	279	53	136			**179**	**89**
60	0	0	0	0	0	0	0	**0**	**0**	134	148	182	226	88	676	1364	**403**	**468**
65	0	0	0	0	0	0		**0**	**0**	1300	2004	1051	2600	344	1087		**1398**	**794**
70	0	0	0	0	0	0		**0**	**0**	3125	2935	2455	3894	5379	5939		**3955**	**1410**
75	0	0	0	0	0	0		**0**	**0**	8628	1223	1088	6922	1125	854		**3307**	**3505**
80	0	1.39	0	0	0	0		**0.2**	**0.6**	338	261	363	188	1603	1233		**664**	**599**
85	0	0.57	0	0	0.64	0		**0.2**	**0.3**	817	162	69	286	185	151		**278**	**273**
90		0	0	0.55	0	0.47		**0.2**	**0.3**		178	272	539	124	176		**258**	**166**
95	0	0	0	0.74	0	2		**0.5**	**0.8**	1554		389	1263	585	143		**787**	**598**
100	0	3.03						**1.5**	**2.1**	0	135						**68**	**95**

Tab. 2.1.15. Vertical distribution of different developmental stages of pelagic fish eggs in May 1999, Gdansk Deep. Mean values.

	Cod	Stages				Sprat	Stages			
Depth , m	All stages	1	2	3	4	All stages	1	2	3	4
5	0	0	0	0	0	20	20	0	0	0
10	0	0	0	0	0	29	28	0	0	0
15	0	0	0	0	0	99	99	0	0	0
20	0	0	0	0	0	183	183	0	0	0
25	0	0	0	0	0	282	282	0	0	0
30	0	0	0	0	0	246	246	0	0	0
35	0	0	0	0	0	402	402	0	0	0
40	0	0	0	0	0	213	213	0	0	0
45	0	0	0	0	0	156	156	0	0	0
50	0	0	0	0	0	228	228	0	0	0
55	0	0	0	0	0	179	179	0	1	0
60	0	0	0	0	0	403	268	92	40	2
65	0	0	0	0	0	1398	846	304	242	5
70	0	0	0	0	0	3955	2514	881	550	10
75	0	0	0	0	0	3307	1958	805	520	24
80	0.2	0.2	0	0	0	664	390	174	99	1
85	0.2	0.2	0	0	0	278	217	34	25	2
90	0.2	0.1	0.04	0	0	215	168	56	34	0
95	0.5	0.5	0	0	0	787	463	167	153	4
100	1.5	1.5	0	0	0	135	126	5	4	0

Tab. 2.1.16. Amount of pelagic fish eggs (n/100m^3) at different depth in June 1999, Gotland Basin. 3-4 parallels BIOMOC sampling.

Depth	Cod				Mean	SD	Sprat				Mean	SD	Flounder				Mean	SD
10	0	0	0		**0**	**0**	5	6	6		**5**	**0**	0	0	0		**0**	**0**
20	0	0	0		**0**	**0**	59	18	27		**35**	**22**	0	0	0		**0**	**0**
30	0	0	0		**0**	**0**	101	64	59		**75**	**23**	0	0	0		**0**	**0**
40	0	0	0		**0**	**0**	214	137	382		**244**	**125**	0	0	0		**0**	**0**
50	0	0	0		**0**	**0**	429	299	324		**351**	**69**	0	0	0		**0**	**0**
60	0	0	0		**0**	**0**	343	342	373		**353**	**17**	0	0	0		**0**	**0**
70	0	0	0		**0**	**0**	450	560	302		**437**	**129**	0	0	0		**0**	**0**
75	0	0	0		**0**	**0**	280	313	285		**293**	**18**	0	0	0		**0**	**0**
80	0		0		**0**	**0**	86		110		**98**	**17**	0		0		**0**	**0**
85	0	0	0		**0**	**0**	129	118	167		**138**	**25**	0	0	0		**0**	**0**
90	0	0	0		**0**	**0**	121	112	179		**138**	**36**	0	0	0		**0**	**0**
95	0	0	0		**0**	**0**	91	88	84		**88**	**3**	0	0	0		**0**	**0**
100	0	0.2	0.2	0.2	**0.2**	**0.1**	27	79	68	49	**56**	**23**	0	0.2	0	0	**0.054**	**0.1**
105	0	0.8	0.2	0.0	**0.2**	**0.4**	48	32	41	25	**36**	**10**	0	0	0	0	**0**	**0**
110	0.5	0.2	0.2	1.1	**0.5**	**0.4**	63	36	32	37	**42**	**14**	0	0	0	0	**0**	**0**
115	0.6	0.7	0.0	2.8	**1.0**	**1.2**	123	22	29	41	**54**	**47**	0	0	0	0	**0**	**0**
120	0	0.0	0.0	4.9	**1.2**	**2.5**	34	10	8	34	**21**	**14**	0	0	0	0.2	**0.059**	**0.1**
135	6.6	0.9	0.4		**2.6**	**3.5**	97	143	15		**85**	**65**	0	0	0		**0**	**0**

Tab. 2.1.17. Amount of pelagic fish larvae (n/100m^3) at different depth in June 1999, Gotland Basin. 3-4 parallels BIOMOC sampling.

Depth, m	Sprat				Mean	SD	Sea snail (Liparis liparis)				Mean	SD	Flounder				Mean	SD
10	0.9	0.7	8.0		**3.2**	**4.1**	0	0.2	0		**0.1**	**0.1**	0	0.2	0.3		**0.2**	**0.1**
20	0.0	0.0	0.3		**0.1**	**0.2**	0	0	0		**0.0**	**0.0**	0	0	0		**0**	**0**
30	0.2	0.3	0.8		**0.4**	**0.3**	0	0	0.3		**0.1**	**0.1**	0	0	0		**0**	**0**
40	0.3	0.3	0.0		**0.2**	**0.2**	0	0.3	0.3		**0.2**	**0.2**	0	0	0		**0**	**0**
50	0.0	0.0	0.0		**0.0**	**0.0**	0	0	0		**0**	**0**	0	0	0		**0**	**0**
60	0.2	0.0	0.0		**0.1**	**0.1**	0.2	0.3	0		**0.2**	**0.1**	0	0	0		**0**	**0**
70	0.7	0.0	0.2		**0.3**	**0.4**	0	0.3	0		**0.1**	**0.2**	0	0	0		**0**	**0**
75	2.8	0.0	0.7		**1.2**	**1.4**	0	0	0		**0**	**0**	0	0	0		**0**	**0**
80	0		0		**0.0**	**0.0**	0		0		**0**	**0**	0		0		**0**	**0**
85	0	0	0		**0.0**	**0.0**	0	0	0		**0**	**0**	0	0	0		**0**	**0**
90	0	0	0		**0.0**	**0.0**	0	0	0		**0**	**0**	0	0	0		**0**	**0**
95	0.3	0	0		**0.1**	**0.2**	0	0	0		**0**	**0**	0	0	0		**0**	**0**
100	0.3	0	0	0.2	**0.1**	**0.1**	0	0	0	0	**0**	**0**	0	0	0	0	**0**	**0**
105	0	0	0	0	**0.0**	**0.0**	0	0	0	0	**0**	**0**	0	0	0	0	**0**	**0**
110	0.5	0	0	0	**0.1**	**0.3**	0	0	0	0	**0**	**0**	0	0	0	0	**0**	**0**
115	0.9	0	0	0	**0.2**	**0.4**	0	0	0	0	**0**	**0**	0	0	0	0	**0**	**0**
120	0	0	0	0	**0.0**	**0.0**	0	0	0		**0**	**0**	0	0	0	0	**0**	**0**
135	0	0	0		**0.0**	**0.0**	0	0	0		**0**	**0**	0	0	0		**0**	**0**

Tab. 2.1.18. Seasonal production values (SP; n*10^{-12}) and mortality coefficients for cod and sprat eggs integrated over the 1999 spawning season.

<table>
<tr><td></td><td colspan="5">Cod</td><td colspan="5">Sprat</td></tr>
<tr><td></td><td>Ia</td><td>Ib</td><td>II</td><td>III</td><td>IV</td><td>Ia</td><td>Ib</td><td>II</td><td>III</td><td>IV</td></tr>
<tr><td>SP</td><td>3.20</td><td>2.67</td><td>1.26</td><td>0.31</td><td>0.14</td><td>58.9</td><td>31.8</td><td>20.8</td><td>10.4</td><td>5.0</td></tr>
<tr><td>z</td><td colspan="2">0.0857</td><td></td><td></td><td></td><td colspan="2">0.3996</td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td colspan="2">0.3263</td><td></td><td></td><td></td><td colspan="2">0.2161</td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td colspan="2">0.3516</td><td></td><td></td><td></td><td colspan="2">0.2509</td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td colspan="2">0.2117</td><td></td><td></td><td></td><td colspan="2">0.3102</td></tr>
<tr><td>DT</td><td colspan="5">14.7 days</td><td colspan="5">10.3 days</td></tr>
<tr><td>C_{hatch}</td><td colspan="5">97.88 %</td><td colspan="5">95.85 %</td></tr>
</table>

Tab. 2.1.19. Mortality of sprat eggs in the different regions of the Gotland Basin and the Gdansk Deep in the different months of 1999. Z is Instantaneous mortality coefficient (per day).

Region	GB	GB	SGB	SGB	GB	GB	SGB	SGB
Month	20 April	20 April	20 April	20 April	May	May	May	May
Stages	St. I-II	St. II-III	St. I-II	St. II-III	St. I-II	St. II-III	St. I-II	St. II-III
Depth	>70m	>70m	>70m	>70m	>70m	>70m	>70m	>70m
Mortality rate	0.161	0.021	0.118	0.115	0.332	0.228	0.331	0.250
Z	-0.175	-0.022	-0.126	-0.122	-0.404	-0.259	-0.4019	-0.288

Region	GB	GB	SGB	SGB	GB	GB	SGB	SGB
Month	20 June	20 June	20 June	20 June	20 June	20 June	20 June	20 June
Stages	St. I-II	St. II-III	St. I-II	St. II-III	St. I-II	St. II-III	St. I-II	St. II-III
Depth	>70m	>70m	>70m	>70m	<70m	<70m	<70m	<70m
Mortality rate	0.337	0.248	0.298	0.331	0.298	0.242	0.360	0.267
Z	-0.411	-0.285	-0.3539	-0.402	-0.3542	-0.277	-0.446	-0.310

	Hauls in the surface layer				BIOMOC			
Region	GB + SGB	GB + SGB	GB + SGB	GB + SGB	GD	GD	GD	GD
Month	20 June	20 June	20 June	20 June	29-30 May	29-30 May	4 July	4 July
Stages	St. I-II	St. II-III	St. I-II	St. II-III	St. I-II	St. II-III	St. I-II	St. II-III
Depth	>70m	>70m	<70m	<70m	>70m	>70m	>70m	>70m
Mortality rate	0.585	0.030	0.801	0.066	0.255	0.135	0.376	0.384
Z	-0.881	-0.031	-1.613	-0.068	-0.294	-0.145	-0.471	-0.485

Tab. 2.1.20. The total amount of the eggs spawned by sprat in the Gotland Basin from 55°30'N to 58°N (ICES subdivisions 26/1, 28/3,4, and the southern halves of 28/1,2) during 1999, and the calculation of its spawning stock biomass in this basin in 1999.

Period	Egg production per day, $n*10^{12}$	Egg production during the whole period, $n*10^{12}$	Mean individual fecundity per spawning season	Number of spawning females, $n*10^{12}$	Spawning sprat number, $n*10^{12}$	Mean weight, g	Total weight of spawning stock of sprat, *1000 t.
April	1.41	42.3					
May	4.26	132.06					
June	5.68	170.4					
The whole spawning season		344.76	11853	0.0291	0.0582	8.8	512

Tab. 2.1.21. Mean relative error in abundance estimates ($_{mean}$), standard deviation ($_{STDV}$) and maximum error ($_{max}$) resulting from spatial sampling resolution for the May 1988 and August 1991 model runs. Calculations are based on the standard 45 stations grid. Ex.1-5=Experiments 1-5 (see Fig. 2a-c); SL=Sprat larvae; SE=Sprat eggs; CL=Cod larvae; CE=Cod eggs.

	May 1988					August 1991				
	Ex.1	Ex.2	Ex.3	Ex.4	Ex.5	Ex.1	Ex.2	Ex.3	Ex.4	Ex.5
SL_{mean}	**5.3**	**10.4**	**3.9**	**10.6**	**10.0**	**11.9**	**9.7**	**24.7**	**17.9**	**14.3**
SL_{STDV}	6.0	4.7	4.3	5.2	6.1	8.9	6.1	11.4	12.6	7.5
SL_{max}	20.3	18.1	18.8	18.1	29.0	40.7	39.0	43.2	70.6	41.3
SE_{mean}	**5.3**	**11.3**	**5.6**	**8.5**	**15.5**	**11.7**	**23.7**	**8.9**	**17.4**	**24.7**
SE_{STDV}	5.4	5.5	4.1	4.5	9.0	9.7	11.1	3.4	13.4	16.1
SE_{max}	20.5	20.2	17.6	19.1	35.7	28.8	41.5	18.4	45.0	55.3
CL_{mean}	**6.5**	**13.3**	**4.2**	**6.5**	**17.4**	**13.4**	**21.1**	**9.5**	**21.3**	**25.9**
CL_{STDV}	4.7	8.1	4.7	4.4	12.2	8.1	11.8	5.1	16.0	18.9
CL_{max}	20.7	26.2	17.9	17.5	41.7	28.3	41.9	18.2	61.9	65.0
CE_{mean}	**9.3**	**1.6**	**15.4**	**10.4**	**5.3**	**5.5**	**6.1**	**18.3**	**14.2**	**5.3**
CE_{STDV}	4.2	1.8	3.4	10.1	3.4	4.6	3.4	8.3	5.4	6.4
CE_{max}	20.5	6.9	23.5	34.8	13.9	22.5	13.2	35.1	23.7	22.3

Tab. 2.1.22. Summary output of the multiple linear regression.

Regression Statistics		
Multiple R	0.94	
R Square	0.88	
Adjusted R Square	0.84	
Standard Error	0.22	t=4.17
Observations	15	

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	3	3.947	1.316	26.094	0.000027
Residual	11	0.555	0.050		
Total	14	4.501			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	7.1951576	0.690	10.43	0.0000005	5.68	8.71	5.68	8.71
Julian Day of the survey	-0.0038047	0.005	-0.77	0.46	-0.01	0.01	-0.01	0.01
Water density at the depth of isooxygen 2ml/l	0.2014555	0.074	2.71	0.02	0.04	0.36	0.04	0.36
Water temperature at 10 m depth	-0.0974754	0.033	-2.92	0.01	-0.17	-0.02	-0.17	-0.02

Tab. 2.1.23. The generalized vertical distribution of sprat eggs in the Gotland Basin and the Gdansk Deep in all month of the spawning season. 0 corresponds to the mean specific gravity of sprat eggs in the specific observation.

Water layer with density diapason, kg*m^{-3}	-3 to -2.5	-2.5 to -2	-2 to -1.5	-1.5 to -1	-1 to -0.5	-0.5 to 0	0 to 0.5	0.5 to 1	1 to 1.5	1.5 to 2	2 to 2.5	2.5 to 3	3 to 3.5
Relative abundance of sprat eggs, %	0.1	0.6	2.8	7.3	14.7	25.5	22.1	15.1	6.9	2.9	1.4	0.4	0.1

Tab. 2.1.24. Ichthyoplankton surveys in 1999- 2000 used in the calculation of the spawning-stock biomass of sprat in the Gotland Basin.

Year	Date	Vessel	Number of stations in the Gotland Basin
1999	20 - 22 April	Alkor	15
1999	27 May - 2 June	Alkor	33
1999	19 - 21 June	Karmena	30
1999	29 July - 2 August	Alkor	24
2000	3 -5 May	Veronika	32
2000	2 -6 June	Alkor	41
2000	17 -18 June	Pavasaris	30

Tab. 2.1.25. Mortality of sprat eggs in the different regions of the Gotland Basin in the different months of 1999. GB is the central part of the Gotland Basin, SGB is the southern part of it. Z = Instantaneous mortality coefficient (per day): $Z = 1/t*\ln(N_{j,m}/N_{i,n})$, where N is daily abundance of eggs at stage.

Region	GB	SGB	GB	SGB	GB	SGB
Date	21 April	20 April	End of May	End of May	20 June	20 June
Stages	St. I-II	St. I-II	St. I-II	St. I-II	St. I-II	St. I-II
Mortality rate per day [1-EXP(-Z)]:	0.176	0.147	0.349	0.344	0.359	0.320
Z	0.194	0.159	0.429	0.422	0.445	0.386
Period of time between the midpoints of 2 stages (t_{i-j}), in days	3.035	3.115	3.55	3.55	3.426	3.426
Ambient water temperature	4.56	4.46	4.00	4.00	4.12	4.12

Tab. 2.1.26. Mortality of sprat eggs in the different regions of the Gotland Basin in the different months of 2000. GB is the central part of the Gotland Basin, NGB and SGB are the northern and southern parts of it. Z= Instantaneous mortality coefficient (per day): $Z = 1/t*\ln(N_{j,m}/N_{i,n})$, where N is daily abundance of eggs at stage.

Region	NGB	GB	SGB	NGB	GB	SGB	GB	SGB
Date	3 May	3 May	3 May	4 June	4 June	4 June	16 June	16 June
Stages	St. I-II	St. I-II	St. I-II	St. I-II	St. I-II	St. I-II	St. I-II	St. I-II
Mortality rate per day	0.302	0.260	0.179	0.312	0.297	0.400	0.280	0.267
Z	0.359	0.302	0.197	0.374	0.3520	0.511	0.328	0.310
Period of time between the midpoints of 2 stages (t_{i-j}), in days	3.970	3.970	3.547	3.311	3.311	3.311	3.140	3.299
Ambient water temperature	3.64	3.64	4.00	4.50	4.50	4.50	4.43	4.25

Tab. 2.1.27. The calculation of the total amount of the eggs spawned by sprat in the Gotland Basin (ICES subdivisions 26/3, 26/4, 28/1-4) during 1999 and the calculation of its spawning stock biomass in this basin in 1999.

Period	Date of ichthyoplankton survey	Egg production per day, n*10^9	Egg production during the whole period, n*10^9
10 April - 9 May	20 April	368	11040 (368*30 days)
10 May - 10 June	28 May-2 June	3107	96317 (3107*31)
11 June - 12 July	20 June	5349	171168 (5349*32)
13 July - 2 August	01 August	20	420 (20*21)
The whole spawning season			278945

Mean individual fecundity per spawning season	Number of spawning females, n*10^9	Spawning sprat number, n*10^9	Mean weight,g	Total weight of spawning stock of sprat, *1000 t
11738	23.76	47.53	8.7	413
Hydroacoustic survey		49.21		

Tab. 2.1.28. The calculation of the total amount of the eggs spawned by sprat in the Gotland Basin (ICES subdivisions 26/3, 26/4, 28/1-4) during 2000 and the calculation of its spawning stock biomass in this basin in 2000.

Period	Date of ichthyoplankton survey	Egg production per day, n*10^9	Egg production during the whole period, n*10^9
16.04-15.05	3 May	374	11220 (374*30 days)
16.05-10.06	3 June	5499	142974 (5499*26)
11.06-10.07	19 June	3358	100736 (3358*30)
Second part of July (precautious evaluation)		1000	20000 (1000*21)
The whole spawning season			274930

Mean individual fecundity per spawning season	Number of spawning females, n*10^9	Spawning sprat number, n*10^9	Mean weight,g	Total weight of spawning stock of sprat, *1000 t
12654	21.73	43.45	9.7	421
Hydroacoustic survey		41.48		

Tab. 2.1.29. The calculation of the total amount of the eggs spawned by sprat in the Gotland Basin (ICES subdivisions 26/3, 26/4, 28/1-4) during 1999 and the calculation of its spawning stock biomass in this basin in 1999 with the assumption that the certain portion of eggs had sunk into the deep water layer with very unfavorable oxygen conditions (<1 ml/l) and died before sampling.

Period	Date of ichthyoplankton survey	Egg production per day, n*10^9	Amount of sprat eggs in the water layer with O_2<1ml/l, %	Corrected egg production per day, n*10^9	Egg production during the whole period, n*10^9
10 April - 9 May	20 April	368	15	433	12988
10 May - 10 June	28 May-2 June	3107	12	3531	109451
11 June - 12 July	20 June	5349	10	5943	190187
13 July - 2 August	01 August	20	5	21	442
The whole spawning season					313068

Mean individual fecundity per spawning season	Number of spawning females, n*10^9	Number of spawning sprat, n*10^9	Mean weight, g	Total weight of spawning stock of sprat, *1000 t
11738	26.67	53.34	8.7	463

Tab. 2.1.30. The calculation of the total amount of the eggs spawned by sprat in the Gotland Basin (ICES subdivisions 26/3, 26/4, 28/1-4) during 2000 and the calculation of its spawning stock biomass in this basin in 2000 with the assumption that the certain portion of eggs had sunk into the deep water layer with very unfavourable oxygen conditions (<1 ml/l) and died before sampling.

Period	Date of ichthyoplankton survey	Egg production per day, n*10^9	Amount of sprat eggs in the layer with O_2<1ml/l, %	Corrected egg production per day, n*10^9	Egg production during the whole period, n*10^9
16.04-15.05	3 May	374	37	594	17810
16.05-10.06	3 June	5499	12	6249	162470
11.06-10.7	19 June	3358	10	3731	111928
Second part of July (precautious evaluation)	-	1	-	1000	21000
The whole spawning season					313208

Mean individual fecundity per spawning season	Number of spawning females, n*10^9	Number of spawning sprat, n*10^9	Mean weight, g	Total weight of spawning stock of sprat, *1000 t
12655	24.75	49.50	9.69	480

Tab. 2.1.31. Location depths (m) of 8 psu isohaline and the upper and lower 4 °C isotherms in the western and eastern parts of the Gdansk Deep

Year	Month	The western part 55°22'N-55°00'N, 19°00'E-19°10'E			The eastern part 55°05'N-54°47'N, 19°23'E-19°35'E			Delta, м		
		8 psu isohaline	4 °C upper isotherm	4 °C lower isotherm	8 psu isohaline	4 °C upper isotherm	4 °C lower isotherm	8 psu isohaline	4 °C upper isotherm	4 °C lower isotherm
1993	early May	61.8	21.3	68.4	65.8	20.7	71.4	-4.3	+0.6	-3.0
1994	late May	68.1	26.6	73.0	57.3	18.9	61.7	+10.8	+7.7	+11.3
1998	late May	66.5	45.1	66.8	66.8	44.8	68.6	-0.3	+0.3	-1.8
	early July	70.7	49.7	70.0	72.4	50.0	71.8	-1.7	-0.3	-1.8
1999	early May	73.2	28.6	76.2	62.0	30.9	64.1	+11.2	-2.3	+12.1
	late May	71.3	44.2	72.6	67.0	29.5	69.7	+4.3	+14.7	+2.9
	early July	71.1	41.5	73.4	63.6	42.2	67.0	+7.5	-0.7	+6.4

Tab. 2.1.32. The Baltic sprat early developmental stages abundance (sp/м^2) in the Gdansk Deep (54°54' - 55°30' N, 18°45' - 19°40' E at depth ≥70 m) in May and the sprat recruitment strength characteristic in 1993, 1994, 1998, 1999

Year	Date	Sprat eggs	Sprat larvae	Sprat recruitment strength characteristic
1993	01-09.05	504.2	25.7	poor
1994	24-28.05	254.4	233.0	strong
1998	23-24.05	656.4	16.5	poor
1999	28-30.05	548.0	38.9	strong

Tab. 2.2.1. Statistical analyses of larval survival during the yolk sac stage of cod at different temperatures (1, 3, 7, 9, 11°C).

	significant		not significant	
female	°C	p-value	°C	p-value
1	1, 3, 7, 9, 11	<0.0001	3, 7, 9	0.209
2	1, 3, 7, 9, 11	<0.0001	3, 7, 9	0.065
3	1, 3, 7, 9, 11	0.0006	3, 7, 9, 11	0.100
4	1, 3, 7, 9, 11	<0.0001	3, 7, 9	0.079
5	1, 3, 7, 9, 11	<0.0001	1, 3, 7, 9	0.094
6	1, 3, 7, 9, 11	<0.0001	3, 7, 9	0.896
7	-	-	1, 3, 7, 9, 11	0.082
8	1, 3, 7, 9, 11	<0.0001	3, 9	0.179
9	3, 7, 9, 11	<0.0001	3, 7, 9	0.225

Tab. 2.2.2. Larval size (after preservation in formaldehyde) of cod at different temperatures (9 larval groups). Average±sd.

Larval length (mm)	Temperature (°C)				
	1	3	7	9	11
At hatching	3.82±0.13	3.72±0.15	3.72±0.11	3.73±0.11	3.57±0.12
At completed yolk sac	4.07±0.17	4.12±0.13	4.02±0.13	4.02±0.12	3.83±0.13

Tab. 2.2.3. Percentage of fertilised eggs of Baltic sprat at different salinities given at three quality levels based on in average egg survival at 10-15 psu.

Fertilisation %

psu	fertilisation >50%	fertilisation >30%	fertilisation >20%
5	14.2±16.1	12.7±14.1	11.4±12.2
7	61.1±15.8	50.8±21.1	40.5±24.6
10	66.9±21.1	56.0±24.7	45.2±27.6
15	59.6±23.5	52.2±22.6	44.2±23.7
n	7	10	14

Table 2.2.4. Viable hatch (±standard deviation), coefficient of variation and significance level (RxC tables using G-test) of Baltic sprat at different temperatures in relation to egg survival at 5°C.

Temperature (°C)	Viable hatch (%)	Coefficient of variation (%)	G (df)	Significance level
2	11.6±12.9	111	327 (3)	P<0.001
3	38.3±17.4	45.4	182 (2)	P<0.001
4	82.3±6.2	7.5	13.0 (1)	P<0.01
5	100±8.5	8.5		

Tab. 2.2.5. Egg parameters of in situ sampled sprat eggs; in average egg specific gravity (g/cm3) and egg diameter (preserved eggs) (mm).

	Bornholm basin			Gdansk basin			Gotland basin	
	April	May/June	July	April	May/June	July	April	May/June
Specific gravity	1.01061	1.00809	1.00655	1.00835	1.00704	1.00624	1.00771	1.00707
Size	1.28	1.33	1.34	1.39	1.38	1.39	1.43	1.42

Table 2.2.6. In average egg specific gravity and egg diameter of sprat eggs obtained by in situ sampling using a “living net” in the Gotland Basin (station BY 10 and BY 15) (SD 28) in 2001.

Station & sample	Date	Egg stage	Egg specific gravity (g/cm^3)	Egg diameter (mm)
BY 10 A	April	I	1,00846±0,00060	1,44±0,06
BY 10 A	April	II	1,00806±0,00043	1.44±0,06
BY 10 B	April	I	1,00827±0,00046	1,43±0,04
BY 10 B	April	II	1,00833±0,00048	1,44±0,05
BY 15 A	May	I	1,00827±0,00049	1,44±0,06
BY 15 A	May	II	1,00794±0,00034	1,44±0,03
BY 10 A	May	I	1,00827±0,00059	1,44±0,07
BY 10 A	May	II	1,00819±0,00047	1,42±0,05
BY 10 B	May	I	1,00830±0,00057	-
BY 10 B	May	II	1,00806±0,00050	-
BY 15 A	June	I	1,00698±0,00044	1,41±0,06
BY 15 A	June	II	1,00682±0,00052	1,44±0,06
BY 15 B	June	I	1,00683±0,00082	1,42±0,05
BY 15 B	June	II	1,00670±0,00031	1,45±0,06
BY 10 A	June	I	1,00698±0,00049	1,41±0,06
BY 10 A	June	II	1,00704±0,00062	1,42±0,06
BY 10 B	June	I	1,00688±0,00047	1,41±0,05
BY 10 B	June	II	1,00688±0,00049	1,42±0,06

Tab. 2.2.7. Sprat egg diameter (preserved eggs) (mm) and dry weight (μg) of in situ sampled eggs in late May/early June. Average±sd.

	Bornholm basin	Gdansk basin	Gotland basin
Dry weight	35.6±1.6	34.6±1.0	36.2±1.6
Egg diameter	1.33±0.07	1.38±0.05	1.42±0.0.06

Table 2.2.8. Dry weight of sprat egg samples obtained by in situ sampling using a “living net” in the Gotland Basin (SD 28) at different times during the spawning season in 2001.

Date	Dry weights (μg)	Average±sd
April	48.2, 47.6	47.9±0.4
May	45.3, 46.2, 45.9, 45.4	45.7±0.4
June	41.6, 37.8, 37.9, 40.0, 44.3, 39.5, 37.0, 36.6	39.3±2.6

Tab. 2.2.9. Sprat egg diameter (preserved eggs) (mm) and egg specific gravity (g/cm3) for eggs obtained by stripping.

	Bornholm basin April		Bornholm basin late May/early June		Gdansk deep late May/early June		Gotland basin late May/early June	
	buoyancy	size	buoyancy	size	buoyancy	size	buoyancy	size
	1.01064	1.27	1.00928	1.26	1.00614	1.51	1.00903	1.24
	1.01145	1.28	1.00903	1.31	1.00654	1.41	1.00895	1.24
	1.01032	1.38	1.01016	1.23	1.00871	1.26	1.00742	1.34
	1.01169	1.27	1.00815	1.36	1.00815	1.38	1.00799	1.31
	1.00992	1.26	1.00614	1.49	1.00928	1.23	1.00710	1.33
	1.01000	1.30	1.00903	1.27	1.00887	1.19	1.00734	1.35
	1.01145	1.26	1.00871	1.31	1.01000	1.25	1.00903	1.35
	1.01040	1.28	1.00847	1.26	1.00903	1.23	1.00952	1.24
	1.01105	1.29	1.01064	1.22	1.00960	1.25	1.00887	1.24
	1.01193	1.22	1.00622	1.37	1.00992	1.22	1.00759	1.39
	1.01185	1.22	1.01000	1.27	1.00903	1.19	1.00799	1.33
	1.00944	1.31	1.00759	1.36	1.00920	1.26		
	1.01177	1.21	1.01097	1.20	1.00799	1.31		
Average	1.01092	1.27	1.00880	1.30	1.00865	1.28	1.00826	1.31
sd	0.00084	0.04	0.00151	0.08	0.00118	0.09	0.00084	0.06

2.2.10. Temperature (°C) and oxygen (ml/l) conditions (±standard deviation) in the principal spawning areas of Baltic sprat, *Sprattus sprattus*, during peak spawning in May-June during the period 1970-2000. Values correspond to the in average occurrence of eggs based on egg specific gravity measurements of eggs obtained by stripping. Number of years at a certain level shown in relation to identified threshold levels for successful egg development.

	SD 25 Bornholm Basin	SD 26 Gdansk Deep	SD 28 Gotland Basin
Temperature (°C)			
average±sd	3,7±1,4	5,0±0,7	5,1±0,4
≥5	4	11	19
>1.25 - <5	23	14	12
≤1.25	2	0	0
<4	13	2	0
Oxygen (ml/l)			
average±sd	5,2±1,7	2,6±1,5	0,4±0,9
≥2	29	16	1
>1.0 - <2	0	1	9
<1.0	0	6	21

Table 2.2.11. Linear regression analysis between environmental conditions at the depths corresponding to the in average egg specific gravity of Baltic sprat during peak spawning and estimated recruitment for Baltic sprat during the period 1970-2000.

SD 25 Bornholm Basin

	n	r^2	t	p	level
temperature –0 group	25	0,078	1,40	0,176	
temperature - age 1	15	0,037	0,71	0,491	
temperature - age 2	16	0,112	1,33	0,205	
temperature - age 3	16	0,444	3,34	0,005	*
oxygen –0 group	25	0,002	0,20	0,840	
oxygen - age 1	15	0,017	-0,47	0,646	
oxygen - age 2	16	0,062	-0,96	0,353	
oxygen - age 3	16	0,011	-0,39	0,699	
layer –0 group	25	0,171	-0,852	0,402	
layer - age 1	15	0,107	-1,30	0,216	
layer - age 2	16	0,062	-0,96	0,354	
layer - age 3	16	0,029	-0,65	0,526	

SD 26 Gdansk Deep

	n	r^2	t	p	level
temperature –0 group	20	0,003	0,22	0,826	
temperature - age 1	12	0,008	0,29	0,776	
temperature - age 2	11	0,099	1,00	0,345	
temperature - age 3	13	0,057	0,81	0,433	
oxygen –0 group	18	0,119	1,47	0,161	
oxygen - age 1	10	0,190	1,37	0,208	
oxygen - age 2	9	0,188	1,28	0,243	
oxygen - age 3	11	0,108	1,04	0,324	
layer –0 group	18	0,214	2,09	0,053	N.B.
layer - age 1	10	0,151	1,19	0,268	
layer - age 2	9	0,112	0,94	0,379	
layer - age 3	11	0,283	1,88	0,093	N.B.

Table 2.3.1: Correlation between successive quarterly averaged reproduction volumes in the Bornholm Basin (* previous year).

Quarters	4^{th*} to 1^{st}	1^{st} to 2nd	2^{nd} to 3rd	3^{rd} to 4^{th}
r	0.342	0.542	0.756	0.858

Table 2.3.2. In average reproductive volumes (RVs) (km^3) for each spawning area and in total for sprat in the Baltic during the period 1966-1999; standard deviation (sd), relative standard deviation (rsd) and share of total RV.

	RVs based on in situ sampling (BIOMOC)				**RVs from measurements on stripped eggs**			
	SD 25	**SD 26**	**SD 28**	**total**	**SD 25**	**SD 26**	**SD 28**	**total**
average	47647	76765	91029	215441	12941	35735	70735	119412
sd	20272	24367	33817	78457	10307	9304	35571	55183
rsd	42.5%	31.7%	37.1%	36.4%	79.6%	26.0%	50.3%	46.2%
share	22.1%	35.6%	42.3%		10.8%	29.9%	59.2%	

Table 3.1.1. Copepod abundance, biomass and production in the Bornholm Sea from April-August 1999.

Species	Stage	Abundance				Specific carbon content				Biomass			
		[Ind./m^2] April	[Ind./m^2] May	[Ind./m^2] June	[Ind./m^2] August	[µgC/Ind.] April	[µgC/Ind.] May	[µgC/Ind.] June	[µgC/Ind.] August	[mgC/m^2] April	[mgC/m^2] May	[mgC/m^2] June	[mgC/m^2] August
Acartia spp.	nauplii	37869	53267	32189	35601	0.14	0.14	0.13	0.11	5.3	7.5	4.2	3.9
Acartia spp.	CI-III	23981	44676	16279	36282	2.06	2.06	1.97	1.78	49.4	92.0	32.0	64.6
Acartia spp.	CIV-V	12692	37218	52059	50654	2.77	2.77	2.77	2.65	35.2	103.2	144.3	134.0
Acartia spp.	adults	10596	47317	100076	109538	4.73	4.73	4.73	5.04	50.1	223.6	472.9	552.1
Acartia spp.	**all stages**	**85138**	**182478**	**200603**	**232075**					**140**	**426**	**653**	**755**
Centropages hamatus	nauplii	18839	92783	37069	88070	0.26	0.26	0.23	0.16	4.9	24.1	8.4	14.1
Centropages hamatus	CI-III	35	18951	21622	24700	1.47	1.47	1.44	1.38	0.1	27.9	31.1	34.1
Centropages hamatus	CIV-V	448	1242	25180	17423	3.78	3.78	3.78	3.78	1.7	4.7	95.2	65.9
Centropages hamatus	adults	8032	1163	5092	19586	11.34	11.34	11.34	10.71	91.1	13.2	57.7	209.8
Centropages hamatus	**all stages**	**27354**	**114140**	**88963**	**149779**					**98**	**70**	**192**	**324**
Pseudocalanus sp.	nauplii	53311	40915	20382	29564	0.62	0.62	0.54	0.38	33.1	25.4	11.0	11.2
Pseudocalanus sp.	CI-III	41297	103774	34340	123480	2.88	2.88	2.51	1.78	118.9	298.9	86.3	219.8
Pseudocalanus sp.	CIV-V	1408	29038	31852	44120	5.04	5.04	5.04	5.04	7.1	146.4	160.5	222.4
Pseudocalanus sp.	adults	7065	4594	3664	3180	9.45	9.45	9.45	10.71	66.8	43.4	34.6	34.1
Pseudocalanus sp.	**all stages**	**103081**	**178321**	**90238**	**200344**					**226**	**514**	**292**	**487**
Temora longicornis	nauplii	141807	139516	42180	185756	0.33	0.33	0.27	0.16	46.8	46.0	11.5	29.7
Temora longicornis	CI-III	1082	210880	37617	27317	1.49	1.49	1.41	1.25	1.6	314.2	53.0	34.1
Temora longicornis	CIV-V	13	44082	130301	74901	3.78	3.78	3.78	3.78	0.0	166.6	492.5	283.1
Temora longicornis	adults	10201	6143	87750	140226	15.12	15.12	15.12	10.71	154.2	92.9	1326.8	1501.8
Temora longicornis	**all stages**	**153103**	**400621**	**297848**	**428199**					**203**	**620**	**1884**	**1849**
Oithona similis	nauplii	22059	39631	21250	26523	0.12	0.12	0.13	0.15	2.7	4.8	2.8	4.0
Oithona similis	CI-III	1876	38866	33573	112139	2.12	2.12	2.54	3.39	4.0	82.4	85.4	380.2
Oithona similis	CIV-V	4149	0	39617	0	2.12	2.12	2.54	3.39	8.8	0.0	100.8	0.0
Oithona similis	adults	72	0	460	432	2.27	2.27	2.27	2.27	0.2	0.0	1.0	1.0
Oithona similis	**all stages**	**28156**	**78497**	**94899**	**139094**					**16**	**87**	**190**	**385**
all copepods	eggs	147836	43980	51867	437884	0.04	0.04	0.04	0.04	6.0	1.8	2.1	17.8
Total sum		**544669**	**998038**	**824418**	**1587375**					**688**	**1719**	**3214**	**3818**

Table 3.1.1. cont.

Species	Stage	Weight-specific production [%/d] April	[%/d] May	[%/d] June	[%/d] August	Community production [µgC/(m²·d)] April	[µgC/(m²·d)] May	[µgC/(m²·d)] June	[µgC/(m²·d)] August	Mean product. [mgC/(m²·mo)] April-August
Acartia spp.	nauplii	2.0	6.8	4.0	4.9	108	508	169	192	**7**
Acartia spp.	CI-III	2.0	6.8	4.0	4.9	1003	6267	1290	3171	**80**
Acartia spp.	CIV-V	2.0	6.8	4.0	4.9	714	7026	5816	6581	**158**
Acartia spp.	adults	2.0	6.8	4.0	4.9	1016	15225	19056	27107	**496**
Acartia spp.	**all stages**					**2841**	**29026**	**26331**	**37051**	**741**
Centropages hamatus	nauplii	3.7	10.7	3.1	3.6	181	2588	258	513	**23**
Centropages hamatus	CI-III	3.7	10.7	3.1	3.6	2	2989	956	1241	**38**
Centropages hamatus	CIV-V	3.7	10.7	3.1	3.6	62	504	2922	2397	**54**
Centropages hamatus	adults	3.7	10.7	3.1	3.6	3361	1415	1773	7636	**96**
Centropages hamatus	**all stages**					**3606**	**7497**	**5909**	**11786**	**211**
Pseudocalanus sp.	nauplii	2.4	8.1	0.1	2.5	790	2050	14	279	**19**
Pseudocalanus sp.	CI-III	2.4	8.1	0.1	2.5	2843	24149	112	5451	**201**
Pseudocalanus sp.	CIV-V	2.4	8.1	0.1	2.5	170	11825	209	5515	**110**
Pseudocalanus sp.	adults	2.4	8.1	0.1	2.5	1596	3508	45	845	**37**
Pseudocalanus sp.	**all stages**					**5398**	**41531**	**380**	**12089**	**367**
Temora longicornis	nauplii	4.7	5.1	1.6	0.3	2195	2330	187	89	**30**
Temora longicornis	CI-III	4.7	5.1	1.6	0.3	76	15899	859	102	**110**
Temora longicornis	CIV-V	4.7	5.1	1.6	0.3	2	8431	7979	849	**155**
Temora longicornis	adults	4.7	5.1	1.6	0.3	7234	4700	21494	4505	**362**
Temora longicornis	**all stages**					**9507**	**31360**	**30519**	**5546**	**657**
Oithona similis	nauplii	4.0	4.0	4.0	4.0	107	192	111	159	**4**
Oithona similis	CI-III	4.0	4.0	4.0	4.0	159	3296	3415	15206	**154**
Oithona similis	CIV-V	4.0	4.0	4.0	4.0	352	0	4030	0	**51**
Oithona similis	adults	4.0	4.0	4.0	4.0	7	0	42	39	**1**
Oithona similis	**all stages**					**624**	**3488**	**7599**	**15404**	**210**
all copepods	eggs									
Total sum		**3.4**	**6.9**	**2.6**	**3.1**	**21976**	**112902**	**70737**	**81877**	**2186**

Table 3.1.2. Cladoceran abundance, biomass (wet weight) and production in the Bornholm Basin in 1999. Arithmetic means (n= 20 stations) and standard deviations (STD) for *B. coregoni maritima*, *E. nordmanni* and *Podon* spp.

Species	Month	Abundance [n*m^{-3}]		Biomass [mg*m^{-3}]		Temperature [ºC]		P/B [% *d^{-1}]	Production [µg*m^{-3} *d]	
		Mean	STD	Mean	STD	Mean	STD		Mean	STD
Bosmina	April	0.9	3.0	0.01	0.04	4.0	0.3	1.6	0.2	0.6
Evadne		22.1	21.1	1.1	1.1	4.0	0.3	1.6	17.8	17.9
Podon		2.1	5.4	0.1	0.2	4.0	0.3	1.6	1.4	3.7
Σ Cladocera		25.0	22.5	1.2	1.1	4.0	0.3	1.6	19.3	18.9
Bosmina	May	13.8	17.1	0.2	0.3	7.4	0.6	3.9	8.2	10.1
Evadne		982.3	585.8	49.1	29.3	7.4	0.6	3.9	1992.4	1274.8
Podon		62.1	48.0	2.5	1.9	7.4	0.6	3.9	100.3	79.8
Σ Cladocera		1058.2	585.8	51.8	30.4	7.4	0.6	3.9	2100.9	1324.9
Bosmina	June	15.3	24.3	0.2	0.3	7.3	0.5	3.9	7.3	14.6
Evadne		3140.0	1347.6	157.0	67.4	7.3	0.5	3.9	6092.3	2665.1
Podon		135.4	91.6	5.4	3.7	7.3	0.5	3.9	210.1	147.9
Σ Cladocera		3290.7	1375.5	162.6	68.3	7.3	0.5	3.9	6309.8	2703.4
Bosmina	August	28405.1	15284.8	400.4	229.3	8.6	0.4	4.8	19295.8	11053.1
Evadne		1540.6	5809.7	79.9	234.6	8.6	0.4	4.8	3848.1	11306.5
Podon		61.6	59.9	2.3	2.3	8.6	0.4	4.8	110.9	112.4
Σ Cladocera		30007.4	13544.6	482.5	229.8	8.6	0.4	4.8	23254.9	11074.3

Table 3.1.3 Overview about sampling times, numbers of larvae caught and diet composition analysis as well as percentage of empty stomachs for cod and sprat larvae.

Ship	Date	cod larvae			sprat larvae		
		caught	in analysis	% empty	caught	in analysis	% empty
RV Alkor	23-30 Apr 87	65	50	74	46	9	100
RV Littorina	31 May - 1 Jun 87	40	33	18.2	36	13	76.9
RV Alkor	3-9 Jul 87	95	78	47.4	970	513	54.2
RV Poseidon	17-18 Aug 87	7	5	40	951	457	55.6
RV Alkor	8-9 Sep 87	27	20	10	372	243	82.7
RV Dana	21-22 Mrz 88	0	0		27	0	
RV Alkor	6-7 Apr 88	48	45	15.6	95	39	61.5
RV Littorina	18-19 May 88	1050	1033	22.1	4925	1514	74.1
RV Poseidon	28-30 Jun 88	46	42	9.5	1132	615	75.3
RV Littorina	30 Jul -2 Aug 88	17	16	6.3	254	192	62.5
RV Alkor	21-23 Sep 88	0	0		9	7	71.4
RV Poseidon	11-13 Oct 88	3	2	0.0	66	45	64.4

Table 3.1.4 Summary of prey items encountered in sprat larvae stomachs. Prey type, prey size, number of prey items found in the stomachs (n), number of larvae feeding on the prey type (N), percentage of the prey type on the total ingested prey items (D) and percentage of larvae feeding on the prey type (P).

Size range of sprat larvae investigated	4-20 mm
Number of sprat larvae in analysis	3647
% empty stomachs	69
Number of sprat larvae with stomach content	1132
Number of identified prey organisms	1746

Prey	Size (mm)	n	N	D(%)	P(%)	n/larvae
Diatomacea	0.06-0.07	14	10	0.80	0.88	0.012
Nauplii	0.17-0.32	821	564	47.02	49.82	0.725
Nauplii parts		70	70	4.01	6.18	0.062
copepod eggs		0	0	0.00	0.00	0.000
Acartia spp.						
CI-III	0.32-0.37	132	105	7.56	9.28	0.117
CIV-V	0.37-0.59	141	104	8.08	9.19	0.125
adult female	0.61-0.76	285	173	16.32	15.28	0.252
adult male	0.61-0.82	15	15	0.86	1.33	0.013
Temora longicornis						
CI-III	0.37	1	1	0.06	0.09	0.001
CIV-V	0.51-0.56	3	3	0.17	0.27	0.003
adult female	0.58-0.87	10	8	0.57	0.71	0.009
adult male	0.63-0.71	5	5	0.29	0.44	0.004
Centroges hamatus						
adult female	0.76-0.78	2	2	0.11	0.18	0.002
adult male	0.83	1	1	0.06	0.09	0.001
Pseudocalanus elongatus minutus						
CI-III	0.34-0.36	2	2	0.11	0.18	0.002
CIV-V	0.53-0.73	6	6	0.34	0.53	0.005
adult female	0.75	1	1	0.06	0.09	0.001
adult male	0.80	1	1	0.06	0.09	0.001
Copepodite parts		82	77	4.70	6.80	0.072
Bosmina corigoni maritima	0.21-0.56	126	42	7.22	3.71	0.111
Evadne normannii	0.36	1	1	0.06	0.09	0.001
Podon spp.	0.53-0.77	12	5	0.69	0.44	0.011
Polychaeta	0.81	1	1	0.06	0.09	0.001
Bivalvia	0.26-0.31	4	4	0.23	0.35	0.004
Gastropoda	0.09	1	1	0.06	0.09	0.001
"Mineral"		9	9	0.52	0.80	0.008
				100.0		1.542

Table 3.1.5 Summary of prey items encountered in cod larvae stomachs. Prey type, prey size, number of prey items found in the stomachs (n), number of larvae feeding on the prey type (N), percentage of the prey type on the total ingested prey items (D) and percentage of larvae feeding on the prey type (P).

Size range of cod larvae investigated	4-16 mm
Number of cod larvae in analysis	1329
% empty stomachs	25
Number of sprat larvae with stomach content	1000
Number of identified prey organisms	2972

Prey		Size (mm)	n	N	D(%)	P(%)	n/larvae
Diatomacea		0.05	1	1	0.03	0.10	0.001
Nauplii		0.17-0.34	2713	864	91.29	86.40	2.713
Nauplii parts			46	46	1.55	4.60	0.046
copepod eggs		0.05-0.12	10	9	0.34	0.90	0.010
Acartia spp.							
	CI-III	-	-	-	-	-	-
	CIV-V	-	-	-	-	-	-
	adult female	0.61	1	1	0.03	0.10	0.001
	adult male	0	0	0	0.00	0.00	0.000
calanoid copepods							
	CI-III	0.29-0.58	98	46	3.30	4.60	0.098
	CIV-V	0.39-0.70	51	35	1.72	3.50	0.051
	adults	0.63-0.73	12	10	0.40	1.00	0.012
Copepodite parts			37	37	1.24	3.70	0.037
Bosmina corigoni maritima		0.41	2	1	0.07	0.10	0.002
Evadne normannii		0.37	1	1	0.03	0.10	0.001
Podon spp.		0	0	0	0.00	0.00	0.000
Polychaeta		0	0	0	0.00	0.00	0.000
Bivalvia		0	0	0	0.00	0.00	0.000
Gastropoda		0	0	0	0.00	0.00	0.000
"Mineral"		0	0	0	0.00	0.00	0.000
			2972		100		

Table 3.1.6. Scheme for the sampling of sprat larvae, juveniles and adults in 1999 and 2000.

Year	Date	Sampling source	Station	Stage	N measure/ N age 1 for adults	N_otolith analyzed
1999	Beg July	Cruise	41,59,39,38b,21,6a	Larva	16	16
1999	25th July	Cruise	9	Larva	26	26
1999	27th July	Cruise	23	Larva	16	16
1999	5th Aug	Cruise	16	Larva	13	13
1999	14-15th August	Cruise	32-33	Larva & juvenile	85	85
1998	Jan-July	Commerc+ Cruise	ICES sqr 39-G5	Adult	1205/187	76
1999	Jan-May	Commerc Cruise	ICES sqr 39-G5	Adult	713/23	23
2000	March	Cruise	ICES sqr 39-G5	Adult	291/100	91

Table 3.1.7. Otolith growth model that was tested in the present study. dO/dt refers to otolith growth rate, TL refers to total length, W refers to alcohole free dry weight and dW/dt refers to growth rate in alcohole free dry weight.

Model	Equation	Otolith model inspired by
1	$dO/dt=a(TL)^{b}$	Mosegaard et al. (1988)
2	$dO/dt=a(dTL/dt)^{b}$	Casselman (1990)
3	$dO/dt=a(W)^{b}$	Mosegaard et al. (1988)
4	$dO/dt=a(dW/dt)^{b}$	Casselman (1990)
5	$dO/dt=b(TL)+a$	Mosegaard et al. (1988)
6	$dO/dt=b(dTL/dt)+a$	Secor and Dean (1989)
7	$dO/dt=b(W)+a$	Mosegaard et al. (1988)
8	$dO/dt=b(dW/dt)+a$	Secor and Dean (1989)

Table 3.1.8. Overview over parameters and their values used to implement energetic model for juvenile cod. All units are in g and mm.

Process	Equation	Parameter value
Otolith measurements	$otoW = aw \cdot otoL^{bw}$	aw= 1.500 [1] bw= 2.420 [1]
	$otoA = aa \cdot otoL^{ba}$	aa= 1.860 [1] ba= 1.696 [1]
	$otoV = av \cdot otoL^{bv}$	av= 0.542 [1] bv= 2.415 [1]
Standard metabolism	$M_{stand} = as \cdot \mathrm{d}otoW/\mathrm{dt}$	as= 0.285 [2]
Routine metabolism	$M_{routine} = ar \cdot \mathrm{d}otoW/\mathrm{dt}$	ar= 1.016 [3]
Otolith opacity	protein= $(opa+opb \cdot otoO) \cdot 10^{-6} \cdot \mathrm{d}otoV/\mathrm{dt}$	opa= 5.063 [4] opb= 0.009 [4]
Protein synthesis	$PS_f = ap_o \cdot PS_o^{bpo}$	ap_o= 4.150 [5] bp_o= 0.637 [5]
	$PS_{f,\ maint} = ap_f \cdot (fishDW/fishDW_{corr})^{bpf}$	ap_f= 0.0142 [6] bp_f= -0.200 [6]
Protein degradation	$PD_f = PS_{f,\ maint} + deg \cdot (PS_f - PS_{f,\ maint})$	deg= 0.404 [7]
Dry weight change	$\mathrm{d}fishDW/\mathrm{dt} = (PS_f - PD_f)/pp$ $\mathrm{d}fishDW/\mathrm{dt} = -M_{routine}$	if $PS_f \geq PS_{f,\ maint}$ if $PS_f < PS_{f,\ maint}$
Weight conversion	$fishDW = wca \cdot fishWW^{wcb}$	wca= 0.201 [1] wcb= 1.117 [1]
Protein content	protein weight= $pp \cdot fishDW$	pp= 0.750 [8]
Saccular epithelium	$mSE = r \cdot otoA \cdot epthick \cdot epdens \cdot wc \cdot pp$	r= 4.5 [9] $epthick$= 0.01 [9] $epdens$= 0.001

[1] Data from this study.
[2] From Schurmann & Steffensen (1997). Standard metabolic rate of juvenile cod reported by these authors were converted to g dry weight day^{-1} with conversion coefficients of 13.5 J mg^{-1} O_2 (Elliott & Davison 1975) and 20 kJ g^{-1} dry weight (Edwards et al. 1972), dry weight= 0.201·wet weight$^{1.117}$ (data from this study). Standard metabolism in g g^{-1} fishDW day^{-1} is described as: $M_{stand} = a \cdot fishDW^{b} \cdot T^{c}$, where a= 0.002, b= -0.18, c= 0.6039 and T= temperature.
[3] Data from this study. Estimated from the d*fishDW*/dt-d*otoW*/dt relationship of fish from the starvation experiment.
[4] From paper **I**.
[5] Estimated from average daily protein deposition and whole body protein synthesis from this study
[6] From Houlihan et al. (1988): The fractional rate of protein synthesis/degradation due to maintenance metabolism, their fractional rate of 0.0142 total body protein (in wet weight for a 300 g cod) was corrected for fish weight using the size-rate relationship $rPS_{f,\ maint} = 0.0142 \cdot (fishDW_{obs}/fishDW_{corr})^{-0.2}$, where $fishDW_{corr} = 0.201 \cdot 300^{1.117}$ g.
[7] In growing cod Houlihan et al. (1988) found the slopes of synthesis and degradation on growth rate to be 0.0138 and 0.00678 respectively and the intercept 0.0142. Rearranging the two equations yields a slope of degradation on growth rate of deg=0.00678/0.0138=0.404
[8] From Holdway & Beamish (1984)
[9] Epithelium to otolith area ratio (*r*): From Saitoh & Yamada (1989), epithelium thickness (*epthick*): From Takagi & Takahashi (1999), Takagi (2000), epithelium density (*epdens*): Assumed to be equal to density of water.

Table 3.1.9.. Summary of models fit (*** p<0.001).

Model	Covariance structure	DF model	Akaike´s Criterion	-2Log Likelihood	Comparison model	X^2	DF comparison
1	Unstructure	27	-508.7	-572.7			
2	Compound symmetry	1	-404.9	-416.9	1	103.8	26***
3	AR(1)	1	-363.5	-375.5	1	145.2	26***
4	Moving average	2	-444.4	-458.4	1	64.3	25***

Table 3.1.10. Result of the TCM for the tested otolith growth models. The R^2 refers to the optimal fitting of the estimated otolith growth for the individual model. R^2- residual refers to the residual from observed vs. estimated otolith growth plotted against date.

Model	Equation	R^2	R^2- residual
1	$dO/dt=1{,}05(TL)^{0{,}196}$	0,451	0,053
2	$dO/dt=2{,}36(dTL/dt)^{0{,}314}$	0,454	0,039
3	$dO/dt=1{,}78(dW)^{0{,}075}$	0,466	0,051
4	$dO/dt=2{,}57(dW/dt)^{0{,}13}$	0,499	0,032
5	$dO/dt=-0{,}035(TL)+1{,}72$	0,427	0,042
6	$0{,}071(dTL/dt)+21{,}1$	0,420	0,058
7	$dO/dt=0{,}187(dW)+1{,}461$	0,450	0,051
8	$dO/dt=5{,}764(dW/dt)+0{,}2369$	0,478	0,045

Table 3.1.11. Overview over the comparison of otolith growth rates in the different pattern intervals Ij. The behaviour patterns are the three scenarios the model was run with 1) fish stay above thermocline (surface), 2) fish stay close to seabed (bottom) and 3) fish undertake daily migrations (migration). a= the proportionality constant of the est= a·obs relationship, r^2= correlation coefficient of this relationship, n= number of observations and p= significance level of comparison between observed and estimated growth rates (paired t-test).

locality	I_j	behaviour pattern	*a*	n	r^2	p
Bank	1	bottom	1.108	50	0.74	ns
	2	bottom	0.858	30	0.94	*
	3	bottom	0.741	14	0.57	***
Slope	1	surface	1.080	50	0.63	ns
	2	surface	0.869	39	0.59	ns
	3	surface	0.721	22	0.46	**
	1	migration	1.114	50	0.52	*
	2	migration	1.010	39	0.61	ns
	3	migration	0.626	22	0.45	***
	1	bottom	1.230	50	0.58	**
	2	bottom	0.953	39	0.61	ns
	3	bottom	0.848	22	0.85	ns

Table 3.1.12. Overview over the last five increments effect on increment width for experimental and field samples. sign. IW: those increments with significant contribution to the complete model ($p<0.05$), $r^2_{(2\,IW)}$: r^2 if only the last two increments are included in the model, and $r^2_{(5\,IW)}$: r^2 including all five previous increments in the model.

sample	treatment/locality	sign. *IW*'s	$r^2_{(2\,IW)}$	$r^2_{(5\,IW)}$
experiment	5 °C, low food	-1, -2, -3, -4, -5	0.43	0.49
	5 °C, high food	-3, -4, -5	0.04	0.11
	10 °C, low food	-1, -3, -4	0.02	0.05
	10 °C, high food	-1, -2, -3	0.13	0.18
	15 °C, low food	-2, -4	0.21	0.25
	15 °C, high food	-1, -2, -3, -4	0.10	0.14
Field	bank	-1, -2, -3, -4, -5	0.50	0.55
	slope	-1, -2, -3, -4, -5	0.47	0.52

Table 3.1.13. Overview over fish and otolith measurements (average ± sd). Fish length in mm, dry weight in g, otolith weight in mg, otolith length measurements in m. Juvenile/pelagic days= days from the secondary primordia to the edge/settlings mark.

Parameter	Demersal Slope			Demersal Bank			Pelagic		
Sample number	50			50			20		
Fish length	69.22	±	21.26	61.64	±	26.16 ***	41.30	±	8.10
Dry weight	0.678	±	0.72	0.64	±	1.36 ***	0.09	±	0.05
Juvenile days	68	±	22	66	±	32 ns	31	±	13
Otolith weight	3.85	±	2.78	3.60	±	5.38 ***	0.55	±	0.36
Otolith total length	1379	±	363	1200	±	552 ***	620	±	185
Otolith length at settling	793	±	160	731	±	242 **			
Pelagic days	28	±	9	27	±	11 ns			
Otolith length at thermocline turnover	956	±	372	764	±	463 **			

Table 3.1.14. The relationship between fish dry weight, length and otolith density during starvation (ln-transformed data, df= 30).

Temperature	Parameter	Estimate	t-value	p
5	intercept	3.063	1.108	0.277
	ln(*SL*)	-0.057	-0.090	0.929
	ln(*fishDW*)	0.037	0.189	0.851
10	intercept	3.487	3.489	0.0015
	ln(*SL*)	-0.170	-0.739	0.466
	ln(*fishDW*)	0.036	0.470	0.642
15	intercept	4.794	6.99	$9.12 \cdot 10^{-8}$
	ln(*SL*)	-0.457	-2.908	0.007
	ln(*fishDW*)	0.181	3.084	0.004

Table 3.1.15. Sensitivities of accumulated growth estimates of juvenile cod reared over a 40 day period to errors in measurement of input variables.

Parameter		Parameter input error	
		+10%	-10%
Otolith measurements	*av*	-0.04	+0.41
	bv	-0.02	+0.25
	aw	~0.00	~0.00
	bw	-0.05	+0.54
	aa	-0.05	+0.04
	ba	-0.05	+0.51
Routine metabolism	*ar*	-0.10	+1.00
Protein synthesis, fish	*apf*	+0.01	-0.09
	bpf	+0.02	-0.14
Protein degradation	*deg*	+0.04	-0.34
Protein content	*pp*	+0.039	-0.40
Saccular epithelium	*r*	+0.04	-0.40
	ed	+0.04	-0.40
	et	+0.04	-0.40
Protein synthesis, otolith	*apo*	-0.06	+0.65
	bpo	+0.12	-1.18
Opacity-otolith protein	*opa*	-0.04	+0.38
	bpa	-0.003	+0.03

Table 3.1.16. R^2 values for the correlation between hatchcheck size and the otolith size at increment numbers 1 to 12 posthatch. The otolith sizes were corrected for the hacthcheck size prior to correlation analysis.

Increment number	R^2 for Hc vs. Corr. Otolith size
1	0,0474
2	0,0695
3	0,0092
4	0,0036
5	0,0159
6	0,0109
7	0,0390
8	0,0045
9	0,0155
10	0,0006
11	0,0119
12	0,0080

Table 3.1.17. Regression coefficients and slope for the otolith size-fish size relationship at different days of capture in cohort A, B and C respectively. *** were significant p<0.001, when no asterisks relationships were not significant (p>0.01).

Day at catch	Cohort A		Cohort B		Cohort C	
	R2	Slope	R2	Slope	R2	Slope
1-July	0.9536***	0.1168				
25-July			0.7616***	0.1005		
27-July					0.9058***	0.1554
5-Aug					0.8519***	0.0993
13-Aug	0.232	0.0426	0.7032	0.2392	0.6633***	0.1169
14-Aug	0.9088	0.1007	0.7922	0.0994	0.7984***	0.1148

Table 3.1.18. Sprat growth rates in mmd^{-1} calculated from the literature. References: Ré and Goncalves 1993 (*), Munk 1993 (!), and calculations derived from data from Alshuth 1988 (”).

Species	Environment	Temperature (˚C)	Length (mm)	Growth mmd^{-1}
sprat	stratified	10-13	Up to 20	0.405*
	mixed	10-13	Up to 20	0.369*
	Mixed	10-16	12	0.47!
	Mixed	10-16	16	0.43!
	stratified	10-16	12	0.13!
	stratified	10-16	16	0.35!
		15	Up to 14	0.24-0.4”

Table 3.1.19. Total body length and dry weight calculated by nonlinear regression analysis for larvae from shallow and deep water layers.

body length in mm	Dry body weight in mg for larvae from shallow waters	Dry body weight in mg for larvae from deep waters
7,5	0,026	0,050
12,5	0,2913	0,4080
17,5	1,4159	1,6235

Table 3.1.20. RNA/DNA ratios from the regression line for starving and fed herring larvae from the lab and mean RNA/DNA ratios of different length classes of sprat from the Bornholm Basin.

Mean length in mm	Starving larvae (herring lab)	Fed larvae (lab herring)	Length in mm	Mean RNA/DNA	Variance
7,5	1,1	1,4	6-8,9	1,3	0,05
10,5	1,2	1,9	9-11,9	1,9	1,58
13,5	1,3	2,3	12-14,9	2,3	0,58
16,5	1,5	2,8	15-17,9	5,4	1,76
19,5	1,6	3,3	18-20,9	2,9	0,53

Table. 3.1.21. Means and p-values (Mann Whitney U-Test) of sprat larvae May/June 1999.

1999	Mean: margin of the basin	Mean: central basin	p
Standard length (mm)	9,92	8,80	0,00
Dry weight (mg)	0,091	0,044	0,01
DNA (µg/larva)	1,70	1,01	0,01
RNA (µg/larva)	4,13	2,80	0,02
RNA/DNA	2,66	3,27	0,01

Table 3.1.22. Means and p-values (Mann Whitney U Test) of sprat larvae May/June 2001.

2001	Mean: margin of the basin	Mean: central basin	p
Standard length (mm)	11,52	9,80	0,00
Dry weight (mg)	0,13	0,07	0,00
DNA (µg/larva)	1,24	0,77	0,00
RNA (µg/larva)	3,19	2,12	0,00
RNA/DNA	2,79	2,81	0,18

Table 3.2.1. Upwelling indexes in various sub-basins of the Baltic Sea with the corresponding length/width scales (U=uwpelling, D=downwelling).

Upwelling/downwelling area	Mean upwelling index (max/min) in % (+ upwelling, – downwelling)	Width in km (perpendicular to the coast	Length in km (alogshore)
Eastern Bothnian Sea	-10 to –20 (-25)	10-40	150
Northern Gulf of Finland	10 to 20 (30)	10-25	150
Southern Gulf of Finland	-10 to –20 (-25)	5-15	200
Hiiumaa	15 to 25 (30)/ -15 to –25 (-30)	10-30 (U) /15-30 (D)	35 (U), 40 (D)
Saaremaa	15 to 25 (30)/ -15 to –25 (-30)	10-45 (U), 5-40 (D)	100 (U), 75 (D)
Gotland	15 to 25 (30)/ -10 to –20 (-25)	10-20 (U) 5-10 (D)	150
Western Baltic Proper	15-30 (40)	5-30	whole coast
Eastern Baltic Proper	-15 to –20 (-25)	5-10	whole coast
Southern Baltic (Polish and German coasts)	-10 to –20 (-30)/ 15 to 30 (40)	5-10 (D),10 (U)	300 (D), 45 (Gdansk), 130 (Rügen)
Island Bornholm (B) and Bornholm Basin (BB)	-20 to –30 /10 to 25 (B), -10 to –20 (BB)	10 (U,D) 85-350 (BB)	30 (U), 20 (D) 120 (BB)
Danish Straits	-30 to –50 / 40 to 60	10-30	Large variations (10…100)

Table 3.2.2. Monthly maximum (upwelling) and minimum (downwelling) indices integrated over the whole simulation period. All the results represent conditions integrated over subdivisions 25, 26 and 28.

	May	June	July	August	September	Mean
Maximum	54	38	56	55	65	37
Minimum	-40	-39	-52	-58	-62	-29

Table 3.2.3. Upwelling frequency in percentage of time (during 1973-1982) for some Swedish coastal sections (Gidhagen, 1987) in comparison to calculated upwelling indices (in parentheses).

Coastal station	July, %	August, %	September, %
Trelleborg	28 (28)	22 (25)	10 (23)
Ystad	28 (21)	22 (22)	11 (11)
Ratan	27 (23)	25 (12)	30 (15)
Bjuröklubb	22 (5)	11 (8)	20 (14)
Karlshamn	18 (25)	23 (22)	20 (22)
Kuggören	16 (18)	16 (14)	27 (24)
Kalmarsund	15 (14)	13 (15)	37 (32)
Sundsvallsb.	7 (12)	6 (4)	18 (12)
Landsort	5 (7)	15 (14)	27 (27)
Husum	2 (7)	2 (2)	14 (10)
Almagrundet	2 (8)	6 (12)	24 (23)
Fårö	0 (4)	0 (2)	0 (5)
Sv. Högarna	0 (1)	0 (6)	0 (5)

Table 4.1. Correlation coefficients between BSI_u and overlap coefficients of cod larvae (45 days) derived for different areas; larvae released in different subareas of the Bornholm Basin (* statistical significant at 95% level)

Potential settling areas after 45 days drift

Release area	>60m	40-60m S	40-60m N	<40m S	<40m N	<14E	>18E
>60m	-0.48*	-0.59*	0.65*	-0.54*	0.68*	0.77*	-0.25
>80m	0.04	-0.62*	0.83*	-0.48*	0.85*	0.00	-0.06
<80m	-0.53*	-0.43	0.60*	-0.50*	0.73*	0.05	-0.15
<80m SW	-0.56*	-0.06	0.58*	0.13	0.69*	0.54*	0.05
<80m SE	0.63*	-0.77*	0.77*	-0.69*	0.75*	-0.64*	-0.07
<80m NE	-0.08	-0.81*	0.72*	-0.79*	0.62*	0.10	-0.25
<80m NW	-0.74*	0.27	0.23	0.28	0.53*	0.24	-0.02

Table 4.2: Annual weighting factors for nauplii abundances derived from biomass estimates in the central Baltic Sea 1986-1997 (1992: no data).

Year	1986	1987	1988	1989	1990	1991	1993	1994	1995	1996	1997
weighting factor	0.95	1.03	0.55	0.70	0.87	1.33	0.23	0.29	0.24	0.45	0.36

Table 4.3. Larval cod survival deviations (%) derived from parameter pertubations for a) 1988, Julian Day 241, initial larval survival 73.3%; and b) 1993, Julian day 201, initial larval survival 11.2%.

a)

	5%		10%		25%	
Temperature	-7.1	6.8	-16.2	13.6	-38.1	28.1
Enounter model						
Prey abundance	18.3	-23.9	30.7	-49	36.4	-10.1
Search Volume	18.8	-23.9	30.7	-47.3	36.4	-10.4
Daylight hours	19.9	-23.9	32.6	-49	n.c.	n.c.
Foraging model						
Minimum weight	-6.4	4.8	-12.7	10.5	-39.2	22.3
Growth model						
Weight	0.8	-0.7	0.8	-1.5	2.2	-2.9
Gained weight	0.8	-1.5	1.9	-2.2	4.2	-5.3
Metabolic costs	-8.7	6.8	-17.6	15	-46.4	30.6
Starvation model						
Treshold	-15.3	16.9	-30.2	28.1	-64.9	36.4

b)

	5%		10%		25%	
Temperature	-11.8	6.3	-1.8	11.6	-14.3	26.8
Enounter model						
Prey abundance	18.3	-7.1	25	-17	318.8	-76.8
Search Volume	18.8	-7.1	25	-16.1	244,6	-64.3
Daylight hours	18.8	-8	27.7	-21.4	n.c.	n.c.
Foraging model						
Minimum weight	-1.8	4.5	-7.1	10.7	-14.3	17.9
Growth model						
Weight	0	0	0	0	1.8	-1.8
Gained weight	0	0	0	0	-1.8	1.8
Metabolic costs	-8.2	6.3	-7.1	17	-16.1	31.3
Starvation model						
Treshold	-9.8	12.5	-10.7	23.2	-27.7	50.9

n.c. – not calculated

Table 4.4: Correlation coefficients between BSI_u and overlap coefficients for cod larvae (45 days) derived for different areas; larvae released in different subareas of the Bornholm Basin (* statistical significant at 95% level).

	Potential settling areas after 45 days drift						
Release area	>60m	40-60m S	40-60m N	<40m S	<40m N	<14E	>18E
>60m	-0.48*	-0.59*	0.65*	-0.54*	0.68*	0.77*	-0.25
>80m	0.04	-0.62*	0.83*	-0.48*	0.85*	0.00	-0.06
<80m	-0.53*	-0.43	0.60*	-0.50*	0.73*	0.05	-0.15
<80m SW	-0.56*	-0.06	0.58*	0.13	0.69*	0.54*	0.05
<80m SE	0.63*	-0.77*	0.77*	-0.69*	0.75*	-0.64*	-0.07
<80m NE	-0.08	-0.81*	0.72*	-0.79*	0.62*	0.10	-0.25
<80m NW	-0.74*	0.27	0.23	0.28	0.53*	0.24	-0.02

Tab. 5.1.1. Number of stations covered in the Bornholm Basin and number of herring and sprat stomachs analyzed as well as average lengths of analysed fish (cm) for every sampling date considered.

month-year	herring			sprat		
	no. of stations	no. of stomachs	average lengths (cm)	no. of stations	no. of stomachs	average lengths (cm)
3-88	12	598	20.8	11	528	11.9
4-88	1	193	22.9	5	200	13.7
6/7-88	8	233	23.6	2	87	13.7
7/8-88	4	165	22.7	3	86	14.1
5/6-90	12	562	23.4	12	506	13.7
4-91	7	283	19.6	9	355	13.7
5/6-91	12	474	21.8	14	526	13.9
7-91	15	473	21.4	14	535	13.8
8-91	11	461	21.3	11	326	14.1
4-92	12	159	21.9	11	441	13.5
5-92	-	-	-	13	446	13.8
4-93	10	138	21.4	10	412	13.3
5/6-93	10	281	19.5	9	292	13.7
4/5-94	16	410	21.8	16	517	13.0
5/6-94	13	311	19.8	14	328	12.8
8-94	14	391	20.6	9	169	14.0
4-95	12	262	21.5	13	555	12.3
5-95	18	451	22.1	18	782	12.4
7-95	19	641	18.9	17	563	13.7
5-96	18	673	20.1	18	883	12.9
7-96	16	644	18.5	16	617	14.1
5-97	11	348	19.6	11	403	12.4
7-97	14	366	19.0	14	393	12.8
5-98	17	241	19.9	17	718	11.4
5-99	8	273	20.2	8	276	12.1

Tab. 5.1.2. Average stomach contents of fish eggs and larvae with standard error (SE) as well as daily rations consumed by individual herring in the Bornholm Basin in terms of total food intake (g wet weight), fish and sprat eggs as well as larvae (numbers); information of the duration of the feeding period (hours, minutes) and the average ambient temperature (°C).

month-year	feeding period	ambient tempe-rature	Stomach content								daily ration consumed per individual herring						
			fish eggs	fish eggs	cod eggs	sprat eggs	fish larvae	fish larvae	cod larvae	sprat larvae	wet weight	fish eggs	cod eggs	sprat eggs	fish larvae	cod larvae	sprat larvae
	(hours, min)	(°C)	(numbers)	SE	(numbers)			SE	(numbers)		(g)	(numbers)					
3-88	11.90	5.85	9.44	0.76	2.87	2.01	0.010	0.005	0.004	0.01	0.14	25.7	7.82	5.5	0.06	0.02	0.04
4-88	14.09	5.68	3.21	0.36	0.07	1.17	0.016	0.012	0	0.02	0.67	9.9	0.21	3.6	0.11	0	0.11
4-91	14.51	4.89	11.68	1.22	2.95	7.46	0.002	0.002	0	0	0.72	34.5	8.67	21.9	0.01	0	0.01
4-92	13.52	6.10	12.08	2.45	4.05	7.76	0.229	0.229	0	0	0.52	38.1	12.80	24.5	1.59	0	0
4-93	14.51	4.48	51.68	7.58	19.09	1.16	0.132	0.084	0	0	0.54	146.6	53.92	3.3	0.98	0	0
4/5-94	15.33	3.82	5.32	1.08	1.89	0.55	0.029	0.021	0	0	0.72	14.6	5.19	1.5	0.23	0	0
4-95	13.48	5.62	10.65	3.43	1.36	2.73	0.102	0.102	0	0	0.44	29.9	3.81	7.6	0.71	0	0
5/6-90	17.06	6.37	11.86	1.34	5.31	6.03	0.053	0.036	0	0.05	2.03	46.0	20.54	23.3	0.46	0	0.46
5/6-91	16.54	4.89	31.53	2.70	9.04	22.22	0.010	0.009	0	0.01	1.31	103.3	29.52	72.6	0.09	0	0.09
5/6-93	16.41	4.48	14.43	1.66	8.40	0.54	0	0	0	0	1.10	44.9	26.02	1.7	0	0	0
5/6-94	17.06	3.82	16.53	1.59	14.80	0.33	0.002	0.002	0	0	1.34	49.0	43.70	1.0	0.02	0	0
5-95	16.18	5.62	5.80	0.49	2.14	1.12	0	0	0	0	1.55	19.9	7.35	3.8	0	0	0
5-96	16.35	3.51	4.97	0.39	1.73	2.73	0.004	0.004	0	0	0.96	13.7	4.77	7.5	0.03	0	0
5-97	16.90	5.34	44.41	6.13	7.59	35.76	0.004	0.003	0	0	0.89	125.6	21.46	101.1	0.04	0	0
5-98	16.43	7.48	2.55	0.48	0.25	2.30	<0.001	<0.001	0	0	0.84	9.3	0.92	8.3	0.01	0	0
5-99	16.43	6.58	2.86	0.40	0.44	2.36	0.302	0.153	0	0.30	2.21	9.2	1.41	7.6	2.48	0	2.48
6/7-88	17.20	5.63	4.48	0.51	2.66	1.29	0.001	0.001	0	0	1.73	16.1	9.55	4.6	0.01	0	0.01
7/8-88	15.45	5.63	3.35	0.74	0.80	0.00	0.006	0.006	0	0	0.74	11.2	2.68	0.0	0.04	0	0.04
7-91	16.56	5.63	13.53	1.81	11.14	2.26	0.002	0.002	0.002	0	2.02	48.1	39.46	8.0	0.02	0.02	0.00
8-91	14.56	5.63	1.72	0.21	1.68	0.01	0.295	0.068	0.034	0.261	1.08	5.5	5.37	0.0	2.20	0.25	1.95
8-94	15.26	4.25	52.13	7.35	50.72	0.27	0.024	0.010	0.009	0	0.70	148.8	144.18	0.8	0.19	0.07	0
7-95	16.23	5.50	42.80	4.68	41.24	0.60	0	0	0	0	1.00	145.5	140.18	2.0	0	0	0
7-96	16.17	4.21	85.05	5.64	81.43	3.58	0.002	0.002	0	0	0.67	249.9	239.24	10.5	0.01	0	0
7-97	16.38	5.59	65.57	8.65	63.92	1.65	0.146	0.051	0	0.15	0.91	185.6	180.89	4.7	1.20	0	1.20

Tab. 5.1.3. Average stomach contents of fish eggs and larvae with standard error (SE) as well as daily rations consumed by individual sprat in the Bornholm Basin in terms of total food intake (g wet weight), fish and sprat eggs as well as larvae (numbers); information of the duration of the feeding period (hours, minutes) and the average ambient temperature (°C).

month-year	feeding period	ambient temperature	Stomach content								daily ration consumed per individual sprat					
			fish eggs	fish eggs	cod eggs	sprat eggs	fish larvae	fish larvae	cod larvae	sprat larvae	wet weight	fish eggs	cod eggs	sprat eggs	fish larvae	sprat larvae
	(hours, min)	(°C)	(numbers)	SE	(numbers)		(numbers)	SE	(numbers)		(g)	(numbers)				
3-88	11.90	5.85	6.17	0.91	0.99	0.26	0.061	0.017	0	0	0.11	17.7	2.8	0.7	0.36	0
4-88	14.09	5.68	27.70	3.65	25.75	0.00	0.011	0.011	0.011	0	0.15	89.0	82.8	0.0	0.08	0
4-91	14.51	4.89	28.67	3.52	3.37	17.24	0	0	0	0	0.18	91.5	10.7	55.0	0	0
4-92	13.52	6.10	35.84	2.91	1.08	26.63	0	0	0	0	0.08	116.0	3.5	81.8	0.03	0
4-93	14.51	4.48	32.51	3.99	5.60	11.95	2.001	0.735	0.031	0.272	0.19	101.6	17.5	37.3	14.86	2.02
4/5-94	15.33	3.82	4.96	0.72	0.63	0.45	0	0	0	0	0.34	15.5	2.0	1.4	0	0
4-95	13.48	4.98	17.35	1.33	3.11	3.51	0	0	0	0	0.08	52.8	9.5	10.7	0	0
5/6-90	17.06	6.37	54.84	4.39	3.98	49.17	0.746	0.343	0	0.731	0.37	210.5	15.3	188.8	6.37	6.25
5/6-91	16.54	4.89	31.43	3.11	7.55	20.80	0.001	0.001	<0.001	0.001	0.36	110.2	26.5	72.9	0.01	0.01
5-92	16.38	6.10	46.92	4.06	1.66	44.24	0	0	0	0	0.36	173.6	6.1	163.7	0	0
5/6-93	16.41	4.48	2.13	0.31	1.24	0.65	0	0	0	0	0.37	7.2	4.2	2.2	0	0
5/6-94	17.06	3.82	11.22	1.37	1.27	6.50	0.013	0.009	0	0	0.39	37.5	4.2	21.7	0.11	0
5-95	16.18	5.62	7.98	0.76	0.28	1.65	0	0	0	0	0.19	28.3	1.0	5.9	0	0
5-96	16.35	3.51	3.29	0.34	0.63	1.34	0.002	0.002	0	0	0.33	10.5	2.0	7.5	0.02	0
5-97	16.90	5.34	27.30	2.60	1.90	4.02	0.003	0.002	0	0	0.28	97.8	6.8	14.4	0.03	0
5-98	16.43	7.48	17.60	1.80	5.60	11.95	<0.001	<0.001	0	0	0.24	53.7	17.1	36.6	<0.01	0
5-99	16.43	6.58	9.90	1.00	0.17	7.56	0.002	<0.001	0	0	0.37	28.4	0.5	21.7	0.02	0
6/7-88	17.20	5.63	3.26	0.83	0	3.26	0	0	0	0	0.25	12.1	0.0	12	0	0
7/8-88	15.45	5.63	0.09	0.05	0	0.00	0	0	0.008	0	0.32	0.3	0.0	0	0	0
7-91	16.56	5.63	13.36	1.14	4.70	7.62	0.023	0.019	0	0.017	0.58	48.9	17.2	27.9	0.19	0.145
8-91	14.56	5.63	0.06	0.02	0	<0.1	0	0	0	0	0.42	0.2	0.0	<0.1	0	0
8-94	15.26	4.25	1.46	0.53	0.98	0.49	0.057	0.049	0	0	0.33	4.7	3.1	1.5	0.44	0
7-95	16.23	6.77	0.20	0.02	0	<0.1	0	0	0	0	0.49	0.2	0.0	0	0	0
7-96	16.17	4.21	17.20	0.41	3.82	1.12	0	0	0	0	0.27	17.2	12.5	3.7	0	0
7-97	16.38	5.59	17.60	4.10	17.65	0.01	0	0	0	0	0.51	60.3	60.5	<0.1	0	0

Tab. 5.1.4. Relative distribution of sprat biomass in different Sub-divisions as derived from hydroacoustic surveys carried out in May/June 1979-1986 by the former GDR, USSR and Poland in comparison to the international hydroacoustic survey conducted annually in September/October (- : no survey data available).

Year	Sub-division 25		Sub-division 26		Sub-division 28	
	May/June	Sept./October	May/June	Sept./October	May/June	Sept./October
1979	0.44	0.05	0.31	0.48	0.26	0.47
1980	-	0.10	-	0.72	-	0.18
1981	0.29	0.24	0.46	0.71	0.25	0.05
1982	0.49	0.38	0.25	0.43	0.26	0.19
1983	-	0.33	-	0.41	-	0.26
1984	0.31	0.26	0.32	0.61	0.37	0.12
1985	-	0.54	-	0.37	-	0.08
1986	0.36	0.37	0.31	0.41	0.33	0.22
Average	0.38	0.28	0.33	0.52	0.30	0.20

Tab. 5.1.5. Comparison of herring (a) and sprat (b) population sizes ($n*10^{-6}$) in the Bornholm Basin for the 60m and 75m depth contours derived by recently conducted hydroacoustic surveys and by downscaling MSVPA-results as well as hydroacoustic surveys in autumn with horizontal distributions from historical hydroacoustic surveys.

a)

date	herring population sizes ($n * 10^{-6}$)					
	hydroacoustic survey May/June		downscaled Dis.-MSVPA		hydroacoustic survey in autumn	
	> 60 m	> 75 m	> 60 m	> 75 m	> 60 m	> 75 m
8-94	3924	2427	2286	1681	2975	2188
5-95	1267	759	1766	925	1433	750
6/7-96	2476	1233	2274	1672	2375	1747
5-99	198	-	2331	1714	2331	1714

b)

date	sprat population sizes ($n * 10^{-6}$)					
	hydroacoustic survey		downscaled VPA/XSA		hydroacoustic survey in autumn	
	> 60 m	> 75 m	> 60 m	> 75 m	> 60 m	> 75 m
8-94	818	542	9661	2389	2771	1092
5-95	7053	3746	55436	17218	9461	5907
6/7-96	6389	4049	18862	7634	4753	1874
5-99	10482	-	29169	18210	2645	1043

Tab. 5.1.6. Herring and sprat population sizes (age 1+) in the central Bornholm Basin based on downscaled area dis-aggregated MSVPA and daily consumption rates of cod eggs by these populations related to daily production rates of cod egg stage IA and standing stocks in the area.

month-year	**population size (n * 10-6)**		**cod egg consumption (n * 10-9)**		**cod eggs (n * 10-9)**	
	herring	**sprat**	**herring**	**Sprat**	**production**	**abundance**
4-88	127	6919	0.0	572.7	30.9	104.9
4-91	115	11678	1.0	125.5	37.2	76.1
4-92	112	17830	1.4	494.6	12.5	22.3
4-93	109	20803	5.9	364.1	58.4	102.2
4/5-94	262	19952	1.4	39.4	53.7	78.3
4-95	107	36673	0.4	347.1	7.4	11.6
5/6-90	1074	8753	22.1	133.8	29.2	59.1
5/6-91	984	10827	29.1	286.8	45.0	113.1
5-92	958	16507	-	101.4	12.4	27.7
5/6-93	928	19348	24.2	81.9	57.6	98.2
5/6-94	850	18722	37.3	79.6	265.9	295.4
5-95	925	34609	6.8	34.1	72.1	197.7
5-96	805	35022	3.8	33.9	40.8	121.8
5-97	586	17216	12.6	117.6	47.8	124.3
5-98	556	20768	0.5	355.9	6.4	14.1
5-99	687	13776	1.0	6.7	19.1	42.8
6/7-88	2201	1122	21.1	0.0	42.7	91.6
7/8-88	2127	1082	5.7	0.0	33.3	86.8
7-91	2049	2305	81.1	39.7	88.8	203.9
8-91	1982	2256	10.7	0.0	46.1	76.8
8-94	1681	3809	243.4	11.8	220.4	947.9
7-95	1872	7086	262.4	0.0	513.0	1170.5
7-96	1672	7436	400.0	93.0	191.7	639.0
7-97	1208	3604	218.6	218.0	208.6	505.6

Tab. 5.1.7. Herring and sprat population sizes (age 1+) in the central Bornholm Basin based on downscaled hydroacoustic survey in autumn and daily consumption rates of cod eggs by these populations related to daily production rates of cod egg stage IA and standing stocks in the area.

month-year	population size (n * 10-6)		cod egg consumption (n * 10-9)		cod eggs (n * 10-9)	
	herring	sprat	herring	sprat	production	abundance
4-88	55	1715	0.0	142.0	30.9	104.9
4-91	65	4297	0.6	46.2	37.2	76.1
4-92	62	4766	0.8	132.2	12.5	22.3
4-93	84	3427	4.5	60.0	58.4	102.2
4/5-94	285	4563	1.5	9.0	53.7	78.3
4-95	89	5777	0.3	54.7	7.4	11.6
5/6-90	593	1751	12.2	26.8	29.2	59.1
5/6-91	559	4686	16.6	124.1	45.0	113.1
5-92	796	4139	-	25.4	12.4	27.7
5/6-93	780	3515	20.4	14.9	57.6	98.2
5/6-94	973	4651	42.7	19.8	265.9	295.4
5-95	750	5907	5.5	5.8	72.1	197.7
5-96	745	7895	3.6	7.6	40.8	121.8
5-97	745	6192	16.0	42.3	47.8	124.3
5-98	1747	1230	0.3	90.2	6.4	14.1
5-99	486	4776	0.7	2.3	19.1	42.8
6/7-88	1118	394	10.7	0.0	42.7	91.6
7/8-88	1138	398	3.1	0.0	33.3	86.8
7-91	1128	1237	44.6	21.3	88.8	203.9
8-91	1083	1324	5.8	0.0	46.1	76.8
8-94	2188	1092	316.8	3.4	220.4	947.9
7-95	1455	1396	203.9	0.0	513.0	1170.5
7-96	1747	1874	417.9	23.4	191.7	639.0
7-97	1747	1230	315.9	74.4	208.6	505.6

Tab. 5.1.8. Herring and sprat population sizes (age 1+) in the central Bornholm Basin (> 60 m depths) and daily consumption rates of sprat eggs by these populations related to standing stocks and sprat egg abundance in the area, - : no data available.

Month-year	**population size** (n * 10^{-6})		**sprat egg consumption** (n * 10^{-9})		**sprat eggs** (n * 10^{-9})
	herring	Sprat	herring	sprat	abundance
3-88	186	11696	1.0	8.7	125
4-88	176	11204	0.6	0.0	360
4-91	180	18420	3.9	1013.1	-
4-92	201	19070	4.9	1560.2	-
4-93	201	22296	0.7	832.4	3511
4/5-94	832	19018	1.5	26.6	2993
4-95	199	28433	1.3	303.6	-
5/6-90	1612	7323	-	1382.4	1522
5/6-91	1529	17269	6.5	1259.7	8703
5-92	1702	18260	110.9	2989.9	5373
5/6-93	1688	19993	2.8	44.4	5711
5/6-94	1599	18368	37.6	399.1	3927
5-95	1704	27579	1.5	161.9	1730
5-96	1625	20504	9.6	152.9	956
5-97	1734	9886	175.3	142.6	4934
5-98	1644	11925	13.7	436.2	3057
5-99	2034	7911	15.5	171.5	3009
6/7-88	2067	3609	18.1	44	15
7/8-88	1983	3458	5.0	0	< 0.1
7-91	2254	5956	0.0	166.0	-
8-91	2175	5805	0.1	< 0.1	< 0.1
8-94	2241	6060	1.7	9.4	-
7-95	2434	9283	12.3	1.5	-
7-96	2383	6942	25.1	25.5	213
7-97	1643	9142	7.7	0.3	1015

Tab. 5.1.9. Dates of ichthyoplankton and pelagic trawl surveys in 1999 (mid-point), number of stations covered in each survey and sprat analysed for sex and maturity stage.

Date of egg survey	No. of stations	Date of trawl survey	No. of stations	Analysed sprat
15.04	46	26.04	15	1178
19.05	41	22.05	14	1738
23.05	37			
05.06	42	05.06	26	2564
01.07	41	07.07	57	4223
27.07	63	-	-	-
06.08	45	13.08	20	1788

Tab. 5.1.10. Daily production of sprat egg stage IA and sprat population size determined for the Bornholm Basin in different month of the spawning season 1999 by daily egg production method (DEPM) applying June and May batch fecundity values in comparison to hydroacoustic survey and down-scaled MSVPA derived estimates.

Date	Egg production (* 10^9)	Population size (* 10^6)			
		DEPM June	May	Hydroacoustic survey	MSVPA
April	229	3144	2457		32869
May	516	5127	3994		29850
June	1379	12100	9489	10482	28794
early July	315	3815	2956		9611

Tab. 5.1.11. Maturity stages for female Baltic sprat (modified after Alekseev and Alekseeva 1996).

Stage	State	Females	Males
I	Juvenile	Gonads are thin, thread-like, colorless and transparent. Sex of fish is not distinguishable by naked eye.	
II	Resting (non-mature)	Ovaries are small, tubular, slender, **yellow-orange**. Oocytes are **not visible by eye**. If the color is dark violett: stage **VI-II**!!!	Testes are thin, flatten, half-transparent and greyish.
III	Ripening	Ovaries increasing the size and at the end of the stage **occupy up to 2/3 of body cavity**. In the beginning of stage oocytes are half-transparent, but at the end of stage non-transparent, yellow. Only at the caudal end (near the ass) there might be some reddish area. Non-transparent and yellow oocytes are **seen by naked eye** through the membrane of ovaries. Diameter of oocytes is 0.2 mm in the beginning of stage and 0.5 mm – at the end of stage. Sub-stages of stage III (differentiation of the ripening females from those who are close to the mature stage) are no longer separated. To distinguish between stage III and IV use the **size** of the oocytes. Oocytes in stage IV are slightly bigger! III is separated from VI-III with the help of the **color** of the ovary (VI-III: reddish violet).	Size of testes has increased and at the end of stage III they occupy most of body cavity. Testes are elastic on touch. At the end of stage, they are white (though real white ones are hardly available). To distinguish from stage IV, a **cross-section** of testes can be done. **Overrun' (overflow) and exude of milt should not occur, the form should be maintained.** III has also a different shape of the testes with a **triangular form**.
IV	Mature (ripe)	Ovaries occupy all empty space in body cavity. Non-transparent oocyte diameter is 0.5-0.6 mm, so oocytes are **slightly bigger than in III**. The color of the ovary is **light yellow**, not reddish!	Testes occupy all body cavity, are elastic and **white**. In cross-section, they '**overrun**' (overflow) exuding thick milk.
IV-V	Pre-spawning	Ovaries occupy all empty space in ventral cavity firmly pressing on all other organs. Through the membrane of ovaries are seen **large** (diameter 0.7-1.0 mm) and transparent (**hydrated) oocytes**. In ovary they are evenly distributed between different size ripening and non-transparent oocytes. There are no eggs available in ovaries cavity. It is **very important** to distinguish between IV-V and **VI-IVh** (a new invention!). IV-V is mostly yellow in contrast to VI-IV which is red-violet (but both are of course a bit transparent).	
V (VI-V)	Spawning	Slight pressure upon the belly extrudes eggs from the genital opening (press before cutting the fish!). **Running** during the day is really seldom!	Slight pressure upon the belly **extrudes thin milk** from the genital opening, so press **before cutting** the fish!!!
VI-III	Partly spawned - ripening	Ovaries are similar to the stage III, but have **reddish-violet** color. Ovaries are soft on touch. In cross-section of ovaries in ovaries cavity are seen separate, not spent eggs. Use the **size** of oocytes to differenciate between VI-III and VI-IV	
VI-IV	Partly spawned – mature	Ovaries are similar to stage IV but reddish-violet. In ovaries cavity can be seen separate, not spent eggs. Do not judge by size of ovary but again by size of oocytes!	Testes are similar to stages III and IV, but **smaller**, soft and **unevenly colored**: Milk is remaining in the upper part (**white areas**), reddish or brownish spots occur.
VI-IVh	NEW!	**New invention** to separate between first time spawners (IV-V) and those which are entering from VI-IV: Similar to IV-V (see above) but the color is **red-violet**!!!	
VI	Spent (Spawned)	Like an early stage III, but Ovaries are **very flabby** (and small), mainly **dark red**, half-transparent. **Small number** of remaining yellow oocytes can be seen through membrane of ovaries. Cross-section of ovaries cavity has large opening in which can be seen separate, not spent or remaining eggs.	Testes are **small**, soft and **flabby**. Colors of testes are red-brawn frequently with white spots. In cross-section, they not 'overrun' (overflow) but small amount of remaining milk is exuded.
VI-II	Post-spawning (Recovering)	**Similar to stage II**: Ovaries are small and half-transparent but the color is **still dark red**. No oocytes can be seen by naked eye.	Testes are small, dense, elastic, non-transparent and **brownish**. In cross-section they **maintaining the shape** and not 'overrun' (overflow).

Tab. 5.2.1. Comparison of weight-at-age in the catch and weight-at-age in the stock for young age-groups of cod, herring and sprat in the central Baltic. Different time series are presented (see text for details).

		Cod Weight at age in the catch in age-group				Weight at age in the stock in age-group		
year	quarter	1	2	3	year	1	2	3
1977-89	1	424.0	325.0	582.0	1977-89	65.0	206.0	
	2	345.0	368.0	592.0		73.0	242.0	
	3	255.0	385.0	609.0		89.0	310.0	
	4	287.0	474.0	710		125.0	460.0	
1990-96	1	232.0	528.0	862.0	1995-97	49.5	275.0	651.0
	2	350.0	498.0	868.0				
	3	326.0	651.0	872.0				
	4	372	764	998				

		Herring Weight at age in the catch in age-group				Weight at age in the stock in age-group		
year	Subdiv.	0	1	2	year	0	1	2
1982-92	25	16.5	41.6	58.1	1982-92	12.3	35.1	53.3
	26	12.3	30.5	49.5		10.4	30.4	44.7
	28	7	14.5	21.7		9.8	24.7	30.9
1993-96	25	16.9	33.3	41.1	1994-97	10.7	26.9	34.1
	26	9.1	24.6	37.2		6.9	21.3	29.6
	28	2.3	17.8	22.6		5.9	17.6	18.4

		Sprat Weight at age in the catch in age-group				Weight at age in the stock in age-group		
year	Subdiv.	0	1	2	year	0	1	2
1982-92	25	4.7	13.2	15.3	1982-92	4.4	12.5	14.9
	26	4.5	12.4	14.5		3.7	10.6	13.2
	28	3.4	10.2	13.2		4.1	10.6	13.3
1993-96	25	3.1	10.2	13.6	1994-97	3.7	10.7	12.5
	26	3.2	6.9	9.5		2.4	7.7	9.5
	28	3.0	8.3	9.7		2.6	7.2	9.1

Tab. 5.3.1. a. Annual predation mortalities of cod age-groups 0, 1 and 2 in the different Sub-divisions (SD) of the Central Baltic Sea.

Age		0			1			2	
year/SD	25	26	28	25	26	28	25	26	28
1977	0.358	0.477	0.467	0.218	0.243	0.219	0.023	0.035	0.022
1978	0.406	0.624	0.591	0.210	0.345	0.367	0.017	0.035	0.040
1979	0.382	0.838	0.771	0.287	0.545	0.587	0.026	0.069	0.065
1980	0.285	0.714	0.543	0.288	0.675	0.533	0.028	0.101	0.077
1981	0.410	0.730	0.589	0.287	0.572	0.587	0.032	0.104	0.061
1982	0.458	0.682	0.749	0.245	0.462	0.523	0.025	0.063	0.055
1983	0.657	1.103	1.209	0.283	0.431	0.635	0.026	0.063	0.081
1984	0.235	0.401	0.541	0.181	0.284	0.418	0.024	0.056	0.052
1985	0.300	0.456	0.439	0.191	0.331	0.326	0.023	0.057	0.042
1986	0.310	0.328	0.225	0.167	0.264	0.244	0.020	0.048	0.034
1987	0.269	0.180	0.174	0.106	0.157	0.095	0.009	0.028	0.012
1988	0.235	0.264	0.151	0.186	0.170	0.107	0.016	0.031	0.016
1989	0.196	0.133	0.063	0.137	0.107	0.068	0.014	0.018	0.011
1990	0.144	0.139	0.046	0.088	0.093	0.031	0.009	0.016	0.004
1991	0.068	0.076	0.022	0.043	0.048	0.015	0.005	0.009	0.002
1992	0.083	0.123	0.017	0.036	0.048	0.009	0.003	0.007	0.001
1993	0.159	0.176	0.025	0.054	0.072	0.010	0.004	0.010	0.001
1994	0.167	0.179	0.027	0.077	0.087	0.013	0.007	0.013	0.002
1995	0.238	0.333	0.028	0.098	0.145	0.014	0.010	0.021	0.002
1996	0.256	0.546	0.020	0.094	0.195	0.010	0.011	0.029	0.001

Tab. 5.3.1. b. Annual predation mortalities of herring age-groups 0, 1 and 2-7 in the different Sub-divisions (SD) of the Central Baltic Sea.

Age		0			1			2-7	
year/SD	25	26	28	25	26	28	25	26	28
1977	0.165	0.538	0.088	0.242	0.650	0.120	0.174	0.420	0.091
1978	0.215	0.608	0.083	0.334	0.919	0.150	0.202	0.683	0.130
1979	0.183	0.745	0.097	0.409	1.351	0.232	0.250	1.055	0.192
1980	0.131	0.752	0.091	0.320	1.549	0.260	0.183	0.914	0.164
1981	0.208	0.710	0.109	0.315	1.207	0.249	0.185	0.910	0.186
1982	0.227	0.635	0.102	0.313	1.051	0.204	0.243	0.889	0.186
1983	0.251	0.679	0.125	0.464	1.055	0.261	0.376	1.037	0.262
1984	0.106	0.453	0.072	0.195	0.665	0.135	0.166	0.689	0.145
1985	0.128	0.444	0.081	0.198	0.699	0.152	0.135	0.484	0.114
1986	0.145	0.411	0.073	0.149	0.586	0.115	0.073	0.392	0.070
1987	0.148	0.303	0.048	0.082	0.345	0.063	0.067	0.176	0.037
1988	0.103	0.501	0.063	0.124	0.404	0.081	0.050	0.187	0.035
1989	0.094	0.364	0.054	0.061	0.243	0.046	0.021	0.108	0.020
1990	0.069	0.241	0.034	0.061	0.209	0.044	0.016	0.057	0.010
1991	0.037	0.126	0.018	0.037	0.111	0.023	0.007	0.026	0.005
1992	0.051	0.125	0.015	0.066	0.133	0.028	0.007	0.018	0.003
1993	0.083	0.177	0.026	0.086	0.190	0.040	0.009	0.020	0.004
1994	0.076	0.217	0.033	0.092	0.225	0.045	0.009	0.023	0.005
1995	0.108	0.248	0.047	0.169	0.378	0.080	0.009	0.024	0.006
1996	0.131	0.254	0.049	0.267	0.526	0.122	0.007	0.018	0.004

Tab. 5.3.1. c. Annual predation mortalities of sprat age-groups 0, 1 and 2-5 in the different Sub-divisions (SD) of the Central Baltic Sea.

Age	0			1			2-5		
Year/SD	25	26	28	25	26	28	25	26	28
1977	0.159	0.713	0.479	0.181	0.646	0.303	0.204	0.608	0.268
1978	0.209	0.887	0.574	0.249	0.980	0.494	0.235	0.917	0.462
1979	0.172	0.993	0.685	0.270	1.238	0.704	0.273	1.296	0.770
1980	0.118	1.034	0.715	0.196	1.350	0.805	0.176	1.148	0.645
1981	0.211	0.883	0.593	0.223	0.867	0.538	0.203	1.083	0.698
1982	0.204	0.801	0.567	0.210	0.924	0.530	0.255	1.082	0.631
1983	0.262	0.774	0.592	0.305	0.701	0.431	0.371	1.091	0.660
1984	0.085	0.482	0.373	0.111	0.497	0.297	0.176	0.765	0.475
1985	0.103	0.503	0.375	0.116	0.532	0.323	0.141	0.526	0.328
1986	0.128	0.521	0.346	0.095	0.490	0.271	0.081	0.507	0.275
1987	0.142	0.413	0.251	0.062	0.303	0.170	0.076	0.225	0.115
1988	0.101	0.740	0.483	0.077	0.319	0.182	0.050	0.227	0.124
1989	0.080	0.522	0.342	0.041	0.209	0.121	0.023	0.125	0.075
1990	0.065	0.347	0.201	0.037	0.175	0.099	0.018	0.080	0.039
1991	0.037	0.209	0.112	0.026	0.095	0.051	0.008	0.035	0.018
1992	0.052	0.255	0.110	0.046	0.123	0.058	0.007	0.027	0.012
1993	0.081	0.279	0.157	0.065	0.171	0.088	0.010	0.023	0.013
1994	0.066	0.316	0.194	0.067	0.206	0.103	0.009	0.025	0.014
1995	0.096	0.272	0.209	0.121	0.312	0.168	0.010	0.025	0.014
1996	0.108	0.283	0.208	0.161	0.377	0.224	0.008	0.021	0.011

Tab. 5.3.2. Annual fishing mortality rates of cod, herring and sprat in the different Sub-divisions (SD) of the Central Baltic Sea.

Species	cod			herring			sprat		
year/SD	25	26	28	25	26	28	25	26	28
1977	0.84	0.79	0.39	0.11	0.16	0.14	0.34	0.32	0.19
1978	0.98	0.50	0.30	0.09	0.06	0.14	0.08	0.27	0.51
1979	1.53	0.28	0.57	0.18	0.12	0.13	0.12	0.23	0.21
1980	0.53	0.69	0.91	0.22	0.18	0.15	0.24	0.44	0.08
1981	0.98	0.81	0.63	0.23	0.19	0.33	0.31	0.22	0.18
1982	0.82	0.51	0.59	0.23	0.10	0.31	0.71	0.49	0.07
1983	0.85	0.57	0.72	0.23	0.12	0.42	0.79	0.14	0.14
1984	1.04	0.68	0.78	0.28	0.14	0.50	0.07	0.17	0.46
1985	0.78	0.74	0.85	0.36	1.10	0.46	0.08	0.22	0.15
1986	0.99	0.82	1.11	0.39	0.31	0.27	0.11	0.30	0.45
1987	0.82	0.76	0.97	0.36	0.27	0.32	0.11	0.45	0.32
1988	0.79	0.75	0.96	0.35	0.36	0.27	0.07	0.52	0.30
1989	1.41	0.93	1.70	0.35	0.32	0.29	0.10	0.05	0.29
1990	0.94	0.80	0.90	0.70	0.28	0.38	0.04	0.09	0.16
1991	1.59	0.67	1.62	0.39	0.24	0.36	0.04	0.14	0.12
1992	0.83	0.57	0.78	0.30	0.20	0.36	0.11	0.27	0.56
1993	0.53	0.31	0.62	0.37	0.30	0.24	0.03	0.07	0.04
1994	0.66	0.48	0.52	0.48	0.36	0.17	0.16	0.18	0.16
1995	0.76	0.42	0.85	0.37	0.33	0.18	0.26	0.16	0.21
1996	0.78	0.48	0.83	0.33	0.39	0.18	0.38	0.27	0.19

Table 6.1.1 Selected parameters estimated outside the model or assumed (H, k, and v - parameters of the differential form of the von Bertalanffy growth equation, $W_{inf}=(H/k)^3$, H=v*h)

Paramet3r	cod	herring	sprat
H	1.06	3.04	4.21
k	0.51	0.70	1.68
v	0.55		
M1	0.20	0.20	0.20

Table 6.1.2 The parameters q, u, and B0 ('000 t) estimated within production models

	cod		herring		sprat	
Parameter	XSA-based model	survey-based model	XSA-based model	survey-based model	XSA-based model	survey-based model
q	1.23	2.19	1.33	1.20	1.58	0.76
u	1.06	1.12	1.48	0.63	0.64	2.36
B0	620	448	1183	1313	212	263

Table 6.1.3 The suitabilities of simulated food components for adult and young cod estimated within production
models

	adult cod		young cod	
food component	XSA-based model	survey-based model	XSA-based model	survey-based model
herring	0.32	0.28		
sprat	1	1	0.50	0.38
young herring	0.62	0.68	0.21	0.20
young sprat	0.32	0.33	0.36	0.34
young cod	0.27	0.24		
other food	0.62	0.64	1	1

Table 6.1.4. Identification of critical life stages of cod and sprat by correlation of production and abundance values of different early life history stages; parameter estimates and their significance level, r^2-values and Durban Watson (DW) statistics indicating serial correlation in the residuals (*significant at 5% level).

Dependent variable	independent variable	Sub-division	Time series	correlation coefficient	p
cod					
potential egg production by SSB	realized egg production (stage I)	25	1976-96	0.80	<0.001
realized egg production (stage I)	late egg production (stage III)	25	1976-96	0.51	0.044
late egg production (stage III)	larval abundance	25	1976-96	0.36	0.173
larval abundance	0-group recruitment	25	1976-95	0.80	<0.001
0-group recruitment	1-group recruitment	25	1976-95	0.99	<0.001
sprat					
SSB	realized egg production (stage I)	26	1977-96	0.66	0.002
realized egg production (stage I)	late egg production (stage III)	26	1973-96	0.82	<0.001
late egg production (stage III)	larval abundance	26	1973-96	0.81	<0.001
larval abundance	0-group recruitment	26	1977-96	0.12	0.617
0-group recruitment	1-group recruitment	26	1977-95	0.99	<0.001
potential egg production by SSB	realized egg production (stage I)	28	1977-96	0.63	0.004
realized egg production (stage I)	late egg production (stage III)	28	1973-96	0.90	<0.001
late egg production (stage III)	larval abundance	28	1973-96	0.48	0.020
larval abundance	0-group recruitment	28	1977-96	0.05	0.824
0-group recruitment	1-group recruitment	28	1977-95	0.98	<0.001

Table 6.1.5. GLM Stock recruitment model - output for cod in Subdivision 25 (recruitment at age 0 and SSB from area dis-aggregated MSVPA):

```
log_R =- 20.56038
     + 4.475488E-9 * SSB
     + -0.00010411 * Nauplia
     +    -0.33572 * NAOWinter
     +     2.42093 * Oxy25
     +     0.57492 * Oxy50
     +    -0.80490 * Oxy75
     +     0.63600 * Oxy100
     +     0.32905 * Temp25
     +     0.56850 * Temp50
     +     0.19459 * Temp100
     +     1.91168 * Dens50
```

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|	Squared Partial Corr Type I
Intercept	1	-20.56038	4.91284	-4.19	0.0011	.
SSB	1	4.475488E-9	1.976829E-9	2.26	0.0413	0.25420
Nauplien	1	-0.00010411	0.00003228	-3.22	0.0066	0.30068
NAOWinter	1	-0.33572	0.03883	-8.65	<.0001	0.12205
Oxy25	1	2.42093	0.43960	5.51	0.0001	0.09652
Oxy50	1	0.57492	0.20289	2.83	0.0141	0.00841
Oxy75	1	-0.80490	0.12255	-6.57	<.0001	0.03392
Oxy100	1	0.63600	0.11694	5.44	0.0001	0.11254
Temp25	1	0.32905	0.09774	3.37	0.0051	0.00009649
Temp50	1	0.56850	0.11762	4.83	0.0003	0.50658
Temp100	1	0.19459	0.08859	2.20	0.0468	0.19059
Dens50	1	1.91168	0.30936	6.18	<.0001	0.74603

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	11	20.31222	1.84657	31.95	<.0001
Error	13	0.75135	0.05780		
Corrected Total	24	21.06357			

Root MSE	0.24041	R-Square	0.9643
Dependent Mean	19.90528	Adj R-Sq	0.9341
Coeff Var	1.20776		

Durbin-Watson Statistics

Order	DW	Pr < DW	Pr > DW
1	2.7052	0.8960	0.1040
2	2.1535	0.5089	0.4911
3	1.9725	0.4355	0.5645
4	1.3939	0.1730	0.8270
5	1.4590	0.1642	0.8358
6	1.8419	0.7191	0.2809
7	1.2596	0.2498	0.7502
8	1.3244	0.3611	0.6389
9	1.3188	0.6454	0.3546
10	1.3010	0.5352	0.4648
11	0.8969	0.2733	0.7267
12	1.1588	0.6493	0.3507

NOTE: Pr<DW is the p-value for testing positive autocorrelation, and Pr>DW is the p-value for testing negative autocorrelation.

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.949926	Pr < W	0.2498
Cramer-von Mises	W-Sq	0.096301	Pr > W-Sq	0.1222
Anderson-Darling	A-Sq	0.542966	Pr > A-Sq	0.1498

Table 6.1.6. GLM Stock recruitment model - output for sprat in Subdivision 26 (recruitment at age 0 and SSB from area dis-aggregated MSVPA):

Selection criterion: Akaike's Information Criterion:

```
R =
       -4.20135E11
     +      215730 * SSB
     +  5489164109 * NAOWinter
     + -2.47304E10 * Oxy25
     + 43498087015 * Oxy50
     + 15424056185 * Oxy75
     + -1.96027E10 * Oxy100
     + -1.08372E11 * Dens25
     + 1.358537E11 * Dens50
     +     1160591 * Nauplia
```

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|	Squared Partial Corr Type I
Intercept	1	-4.20135E11	1.334984E11	-3.15	0.0062	.
SSB	1	215730	63331	3.41	0.0036	0.06201
NAOWinter	1	5489164109	2178914548	2.52	0.0228	0.04953
Oxy25	1	-2.47304E10	14612962304	-1.69	0.1100	0.00054328
Oxy50	1	43498087015	22008171215	1.98	0.0656	0.05774
Oxy75	1	15424056185	8052632520	1.92	0.0735	0.09964
Oxy100	1	-1.96027E10	4418020323	-4.44	0.0004	0.28133
Dens25	1	-1.08372E11	37275310298	-2.91	0.0103	0.08211
Dens50	1	1.358537E11	37696024520	3.60	0.0024	0.39095
Nauplien	1	1160591	707053	1.64	0.1202	0.14413

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	9	1.04552E22	1.161689E21	5.06	0.0024
Error	16	3.672325E21	2.295203E20		
Corrected Total	25	1.412752E22			

Root MSE	15149928487	R-Square	0.7401
Dependent Mean	32173638462	Adj R-Sq	0.5938
Coeff Var	47.08802		

Durbin-Watson Statistics

Order	DW	Pr < DW	Pr > DW
1	2.1348	0.3786	0.6214
2	1.8796	0.3620	0.6380
3	1.4550	0.0766	0.9234
4	2.2556	0.9099	0.0901
5	1.6001	0.4083	0.5917
6	2.0656	0.8689	0.1311
7	2.4135	0.9872	0.0128
8	1.1508	0.1371	0.8629
9	1.3118	0.4446	0.5554
10	1.3855	0.6291	0.3709
11	1.0167	0.3221	0.6779
12	1.2897	0.7855	0.2145

NOTE: Pr<DW is the p-value for testing positive autocorrelation, and Pr>DW is the p-value for testing negative autocorrelation.

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.941598	Pr < W	0.1466
Cramer-von Mises	W-Sq	0.080486	Pr > W-Sq	0.2027
Anderson-Darling	A-Sq	0.532204	Pr > A-Sq	0.1628

Tab. 6.1.6 continued

Selection criterion: significance of the included variables:

```
R =
       -4.58749E11
     +      163985 * SSB
     +  7333332287 * NAOWinter
     + -3.50207E10 * Oxy25
     + 69695795862 * Oxy50
     + -1.41017E10 * Oxy100
     +  -8.5945E10 * Dens25
     + 1.171269E11 * Dens50
```

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|	Squared Partial Corr Type I
Intercept	1	-4.58749E11	1.408226E11	-3.26	0.0044	.
SSB	1	163985	63746	2.57	0.0192	0.06201
NAOWinter	1	7333332287	2185298267	3.36	0.0035	0.04953
Oxy25	1	-3.50207E10	14994008585	-2.34	0.0313	0.00054328
Oxy50	1	69695795862	19879035668	3.51	0.0025	0.05774
Oxy100	1	-1.41017E10	3493749618	-4.04	0.0008	0.34273
Dens25	1	-8.5945E10	38945549195	-2.21	0.0406	0.07638
Dens50	1	1.171269E11	39676879849	2.95	0.0085	0.32621

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	7	9.27577E21	1.32511E21	4.92	0.0030
Error	18	4.851754E21	2.695419E20		
Corrected Total	25	1.412752E22			

Root MSE	16417730561	R-Square	0.6566
Dependent Mean	32173638462	Adj R-Sq	0.5230
Coeff Var	51.02852		

Durbin-Watson Statistics

Order	DW	Pr < DW	Pr > DW
1	2.0798	0.3731	0.6269
2	2.1753	0.6278	0.3722
3	1.3472	0.0605	0.9395
4	1.7585	0.5127	0.4873
5	1.6727	0.4775	0.5225
6	1.5609	0.5073	0.4927
7	1.8801	0.8194	0.1806
8	1.3450	0.3278	0.6722
9	1.2996	0.4373	0.5627
10	1.5129	0.7377	0.2623
11	1.3962	0.7198	0.2802
12	1.2620	0.7295	0.2705

NOTE: Pr<DW is the p-value for testing positive autocorrelation, and Pr>DW is the p-value for testing negative autocorrelation.

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.960154	Pr < W	0.3946
Cramer-von Mises	W-Sq	0.05502	Pr > W-Sq	>0.2500
Anderson-Darling	A-Sq	0.336199	Pr > A-Sq	>0.2500

Table 6.1.7. Statistical results of fitting spawner biomass-recruitment-environment models to Baltic Sea sprat data with and without environmental input terms. Year-classes included in the analyses are those for which both spawner biomass and recruitment data were available (1974-1999). $R^2_{adj.}$, P, SE_{est} and DW represent respectively the variation explained by the model (adjusted for the number of degrees of freedom in the model), statistical significance of the variables and model, standard error of the estimated ln recruitment and the Durbin-Watson test statistic for autocorrelation. Statistical significance is shown sequentially for each input variable and for the entire model. T, ICE and NAOJF represent respectively May temperature in the Bornholm Basin from the depth layer 45 – 65 m, the maximal areal extent of ice coverage in the winter preceding spawning and the North Atlantic Oscillation index averaged for the months of January and February.

Model name	Fitted Model	R^2_{adj} (%)	P_x	$P_{overall}$	SE_{est}	DW
-	Ln R = 16.55 + 0.35*T	28	0.0029	0.0029	0.724	2.23
-	Ln R = 18.61 – 0.0045*ICE	24	0.0054	0.0054	0.740	2.33
-	Ln R = 17.61 + 0.26*NAOJF	22	0.0081	0.0081	0.751	2.35
-	Ln R = 17.3 + 7.5×10^{-7} SSB	13	0.0401	0.0401	0.806	2.16
-	Ln R = 16.4 + 4.3×10^{-7} SSB + 0.29*T	29	0.2175 ; 0.0197	0.0079	0.729	2.29
-	Ln R = 18.1 + 4.9×10^{-7} SSB – 0.0037*ICE	27	0.1605 ; 0.0273	0.0106	0.738	2.41
-	Ln R = 17.2 + 6.2×10^{-7} SSB + 0.23*NAOJF	30	0.0591 ; 0.0152	0.0063	0.722	2.53
Cushing	Ln R = 12.6 + 0.39ln SSB	6	0.1157	0.1141	0.836	2.05
	Ln R = 14.7 + 0.15ln SSB + 0.32T	25	0.5246 ; 0.0146	0.0140	0.748	2.20
	Ln R = 16.0 + 0.19ln SSB – 0.0040ICE	22	0.4255 ; 0.0231	0.0210	0.761	2.32
	Ln R = 13.6 + 0.30ln SSB + 0.24NAOJF	23	0.1167 ; 0.0158	0.0119	0.751	2.40
Ricker	Ln R = 12.6 + ln SSB – 0.61*SSB	6	0.0172	0.1141	0.836	2.05
	Ln R = 4.3 + ln SSB – 9.9×10^{-7} SSB + 0.27T	8	0.0172 ; 0.0514	0.1560	0.830	1.90
	Ln R = 5.81 + ln SSB – 9.3×10^{-7} SSB – 0.0034ICE	5	0.0234 ; 0.0719	0.2073	0.840	1.98

Table 6.1.7. (continued):

Model name	Fitted Model	R^2_{adj} (%)	P_x	$P_{overall}$	SE_{est}	DW
	Ln R = 4.9 + ln SSB – $8.1x10^{-7}$ SSB + 0.22NAOJF	10	0.0250 ; 0.0282	0.0846	0.817	2.14
Beverton-Holt	Ln R = ln(SSB/(b + a*SSB))	0		-		-
	Ln R = ln(SSB/($6.6x10^{-8}$ –$3.4x10^{-4}$*SSB)) + 0.35T	24	0.9590 ; 0.0068	0.0172	0.754	2.17
	Ln R = ln(SSB/(b –a*SSB)) + c*ICE	0		-		-
	Ln R = ln(SSB/(b + a*SSB)) + c*NAOJF	0		-		-
Shepherd	Ln R = a + lnSSB – ln(1 + $(SSB/b)^c$)	0		-		-
	Ln R = a + lnSSB – ln(1 + $(SSB/b)^c$) + d*T	0		-		-
	Ln R = a + lnSSB – ln(1 + $(SSB/b)^c$) + d*ICE	0		-		-

Table 6.1.8. Stock recruitment relationships (age-group 0) for sprat in different Sub-divisions with incorporated variables identified to affect critical life stages; parameter estimates and their significance level, r^2-values and Durban Watson (DW) statistics indicating serial correlation in the residuals (* significant at 5% level).

Dependent variable	Sub-division	Time series	Independent variables	Parameter estimates	p	r^2	DW statistics
recruitment at age 0	26	1977-96	SSB	57466	0.028	0.33	1.97
MSVPA			temperature in intermediate water	$8.948*10^9$	0.062		
			intercept	$-1.714*10^{10}$	0.313		
recruitment at age 0	26	1979-96	SSB	57632	0.030	0.38	1.87
MSVPA			growth anomaly 3rd to 2nd quarter	$5.629*10^7$	0.045		
			intercept	$1.520*10^{10}$	0.037		
recruitment at age 0	26	1977-94	SSB	81450	0.352	0.25	1.51
MSVPA			wind speed anomaly May/June	$-1.493*10^9$	0.837		
			intercept	$1.086*10^{10}$	0.193		
recruitment at age 0	26	1977-96	SSB	57173	0.035	0.41	1.99
MSVPA			temperature in intermediate water	$6.132*10^9$	0.216		
			growth anomaly 3rd to 2nd quarter	$4.810*10^7$	0.084		
			intercept	$-6.182*10^9$	0.732		
recruitment at age 0	26	1981-96	SSB	39214	0.014	0.42	2.42
hydroacoustic survey			temperature in intermediate water	$4.627*10^9$	0.104		
			intercept	$-1.768*10^{10}$	0.105		
recruitment at age 0	25	1977-96	SSB	62234	0.014	0.45	1.93
MSVPA			temperature in intermediate water	$5.930*10^9$	0.051		
			intercept	$-4.309*10^9$	0.680		
recruitment at age 0	25	1978-96	SSB	74645	0.011	0.28	1.90
MSVPA			weight at age anomaly 1st quarter	$2.046*10^8$	0.557		
			intercept	$1.352*10^{10}$	0.098		
recruitment at age 0	25	1977-94	SSB	70176	0.023	0.38	1.67
MSVPA			wind speed anomaly May/June	$4.504*10^9$	0.541		
			intercept	$1.414*10^{10}$	0.069		
recruitment at age 0	25	1981-96	SSB	7469	0.038	0.22	2.23
hydroacoustic survey			temperature in intermediate water	$1.700*10^8$	0.646		
			intercept	$-1.120*10^9$	0.477		
recruitment at age 0	28	1977-96	SSB	25294	0.196	0.08	2.32
MSVPA			temperature in intermediate water	$4.721*10^9$	0.245		
			intercept	$-9.721*10^8$	0.563		
recruitment at age 0	28	1986-96	SSB	48215	0.120	0.13	2.37
MSVPA			growth anomaly 3rd to 2nd quarter	$3.710*10^7$	0.225		
			intercept	$7.344*10^9$	0.118		
recruitment at age 0	28	1977-94	SSB	52705	0.042	0.16	2.08
MSVPA			wind speed anomaly May/June	$-3.017*10^9$	0.335		
			intercept	$7.249*10^9$	0.033		
recruitment at age 0	28	1981-96	SSB	24865	0.006	0.60	1.92
hydroacoustic survey			temperature in intermediate water	$4.449*10^9$	0.021		
			intercept	$-1.763*10^{10}$	0.191		

Table 6.1.9. Estimated $B_{i,y}$, Proportions of overall spawning stock of cod spawning in each sub-division of the Baltic Sea, 1966-2000. Italics indicate assumed values.

Year	SD25	SD26	SD28
1966	*0.36*	*0.42*	*0.22*
1967	*0.36*	*0.42*	*0.22*
1968	*0.36*	*0.42*	*0.22*
1969	*0.36*	*0.42*	*0.22*
1970	*0.36*	*0.42*	*0.22*
1971	*0.36*	*0.42*	*0.22*
1972	*0.36*	*0.42*	*0.22*
1973	*0.36*	*0.42*	*0.22*
1974	*0.36*	*0.42*	*0.22*
1975	*0.36*	*0.42*	*0.22*
1976	0.40	0.42	0.17
1977	0.36	0.41	0.23
1978	0.32	0.43	0.26
1979	0.30	0.50	0.20
1980	0.40	0.44	0.16
1981	0.39	0.42	0.19
1982	0.42	0.40	0.17
1983	0.38	0.42	0.20
1984	0.40	0.41	0.19
1985	0.45	0.36	0.19
1986	0.47	0.38	0.16
1987	0.50	0.38	0.11
1988	0.55	0.35	0.10
1989	0.59	0.35	0.06
1990	0.57	0.34	0.09
1991	0.52	0.44	0.04
1992	0.60	0.37	0.03
1993	0.70	0.26	0.04
1994	0.57	0.39	0.03
1995	*0.62*	*0.34*	*0.04*
1996	*0.62*	*0.34*	*0.04*
1997	*0.62*	*0.34*	*0.04*
1998	*0.62*	*0.34*	*0.04*

Table 6.1.10. Estimated P_i , average relative productivity of spawning in each Sub-division. Values are given relative to spawning in SD 25.

Subdivision	25	26	28
P_i	1	0.87	0.87

Table 6.1.11. Estimated weightings for the effects of oxygen (OW_y) and food (FW_y) availability on egg and larval survival, and overall estimates of effective reproductive environment (ERE_y).

Year, y	OW_y	FW_y	ERE_y
1966	0.544	1.000	0.544
1967	0.670	0.912	0.612
1968	0.106	1.000	0.106
1969	0.605	0.454	0.274
1970	0.459	0.754	0.346
1971	0.049	1.000	0.049
1972	0.639	1.000	0.639
1973	0.213	1.000	0.213
1974	0.479	1.000	0.479
1975	0.083	1.000	0.083
1976	0.833	1.000	0.833
1977	0.555	1.000	0.555
1978	0.429	0.538	0.231
1979	0.470	1.000	0.470
1980	0.590	1.000	0.590
1981	0.199	1.000	0.199
1982	0.093	1.000	0.093
1983	0.399	0.477	0.190
1984	0.488	0.929	0.454
1985	0.371	0.985	0.366
1986	0.303	1.000	0.303
1987	0.231	1.000	0.231
1988	0.144	1.000	0.144
1989	0.027	1.000	0.027
1990	0.064	1.000	0.064
1991	0.366	0.685	0.251
1992	0.412	0.752	0.310
1993	0.557	0.400	0.223
1994	0.478	0.381	0.182
1995	0.310	0.322	0.100
1996	0.338	1.000	0.338
1997	0.197	1.000	0.197
1998	0.128	1.000	0.128

Table 6.1.12. Results of multiple linear regression analyses explaining variability in cod egg stage III daily production rates, larval and 0-group abundance in Sub-division 25; parameter estimates and their significance level, r^2-values, Durbin Watson (DW) statistics indicating serial correlation in residuals (* significant at 5% level), PEP: potential egg production by the spawning stock, RV: reproductive volume, ORV: oxygen content in the reproductive volume, OES: oxygen related egg survival factor.

Model	Dependent variable	Nmber of years	Independent variables	Parameter estimates	p	r^2	DW
1	egg production stage III	15	intercept	$-6.503*10^{9}$	0.137		
			PEP	$7.756*10^{-4}$	<0.001	0.61	1.91
2			Intercept	$8.787*10^{9}$	0.102		
			PEP	$6.832*10^{-4}$	0.006	0.58	2.24
			RV	$3.153*10^{7}$	0.415		
3			Intercept	$-8.063*10^{9}$	0.049		
			PEP	$6.055*10^{-4}$	0.049	0.68	2.38
			ORV	$8.298*10^{7}$	0.004		
4			Intercept	$-7.655*10^{8}$	0.757		
			PEP * OES	$9.560*10^{-4}$	<0.001	0.73	1.91
5	larval abundance	16	Intercept	$4.064*10^{8}$	0.967		
			PEP	$1.002*10^{-3}$	0.022	0.32	1.37
6			Intercept	$-6.591*10^{9}$	0.581		
			PEP	$7.631*10^{-4}$	0.112	0.28	1.32
			RV	$9.178*10^{7}$	0.301		
7			intercept	$-4.108*10^{9}$	0.633		
			PEP	$5.742*10^{-4}$	0.145	0.48	1.34
			ORV	$2.226*10^{8}$	0.023		
8			intercept	$7.473*10^{9}$	0.274		
			PEP * OES	$1.265*10^{-3}$	0.009	0.39	1.02*
9	0-group recruitment	16	intercept	$-1.135*10^{7}$	0.970		
			PEP	$2.238*10^{-5}$	0.081	0.20	0.66*
10			intercept	$-4.209*10^{8}$	0.196		
			PEP	$8.385*10^{-6}$	0.492	0.36	1.24
			RV	$5.371*10^{6}$	0.033		
11			intercept	$-2.132*10^{8}$	0.217		
			PEP	$3.238*10^{-6}$	0.661	0.75	1.65
			ORV	$9.956*10^{6}$	<0.001		
12			intercept	$5.693*10^{7}$	0.761		
			PEP * OES	$3.577*10^{-5}$	0.009	0.40	0.69*

Table 6.1.13. ARIMA modelling procedure set-up to predict environmental conditions affecting recruitment of cod and sprat in Subdivision 25 and 26 respectively.

ARIMA (d,p,q) where d is the order of differencing, p is the order of the autoregressive component, and q that of the moving average component. Given the order of d, p, q in brackets means exclusively this specific order (subset model), otherwise it means up to this order. For instance, ARIMA (1 1, (5), 2) addresses an instationary process and thus a model consisting of an autoregressive component (AR component) of exactly order 5 (p=(5)) and a moving average component (MA component) of order up to 2 (q =2 = 1 and 2) which has been stationarized by taking first-first differences (d=1 1).

The concrete results relevant for cod in SD 25 fulfilling the above assumptions are

Oxy 25 = ARIMA(1, (6),(6)) based on first differenced data
Oxy 50 = ARIMA(1, 0, (5)) based on first differenced data
Oxy 75 = ARIMA(1, 0, 1) based on first differenced data
Oxy 100 = ARIMA(1, 3, 0) based on first differenced data

Temp 25 = ARIMA(1, (5), (5)) based on first differenced data
Temp 50 = ARIMA(1 1, 1, 0) based on first-first differenced data
Temp 100 = ARIMA(1, 1, 1) based on first differenced data

Dens 50 = ARIMA(1, 2, 0) based on first differenced data

Nauplia = ARIMA(0, (4), 0) based on detrended residuals
SSB = ARIMA(0, 1, 0) based on detrended residuals

The concrete results relevant for sprat in SD 26 fulfilling the above assumptions are

Oxy 25 = ARIMA(1, 1, 0) based on first differenced data
Oxy 50 = ARIMA(1, 1, 0) based on first differenced data
Oxy 75 = ARIMA(1, 2, 0) based on first differenced data
Oxy 100 = ARIMA(1, 1, 0) based on first differenced data

Temp 25 = ARIMA(1, 1, 0) based on first differenced data
Temp 100 = ARIMA(1, (5), 0) based on first differenced data

Sal 25 = ARIMA(1, 1, 0) based on first differenced data
Sal 50 = ARIMA(1, 1, 1) based on first differenced data
Sal 75 = ARIMA(1, 2, 0) based on first differenced data

Dens 25 = ARIMA(1 1, 3, 0) based on first-first differenced data
Dens 50 = ARIMA(1 1, 3, 0) based on first-first differenced data
Dens 75 = ARIMA(1, 2, 0) based on first differenced data
Dens 100 = ARIMA(1, 1, 0) based on first differenced data

Nauplia = ARIMA(1, 3, 0) based on first differenced data
SSB = ARIMA(1 1, (1), 0) based on first-first differenced data

Tab. 6.2.1. Year-class strength at age 2 as used in short-term predictions by the Assessment WG in 1997 (ICES 1997), in 1998 (ICES 1998), in 1999 (ICES 1999) and in 2000 (ICES 2000), as derived from the recruitment – larval abundance relationship and as estimated from the latest stock assessment (ICES 2002) assumed to be the best available estimate.

Year-class	WG estimate* ($* 10^6$)	Larval abundance based ($* 10^6$)	Best estimate ($* 10^6$)
1995	160	64.5	77.3
1996	163	73.7	117.1
1997	150	75.8	124.1
1998	156	69.2	128.5
1999	112	67.5	161.0

* a constant estimate was applied for all three year-classes to be estimated in a short-term prediction, i.e. using the value for year-class 1995 as recruitment in the calculation for the assessment year 1997, the prediction year 1998 and the final year 1999.

Table 6.2.2. Short term predictions of eastern Baltic cod stock yield and SSB (t) using various year ranges (from last year only to an average of the last 10 years) for mean weight at age in the stock and in the catch (status quo fisheries).

	Yield						**SSB**				
Year	**last year**	**last two**	**last thee**	**last five**	**last ten**		**last year**	**last two**	**last thee**	**last five**	**last ten**
2002	76580	79147	82617	86910	93958		82978	81356	84238	98395	111483
2003	75812	78380	81618	85836	92445		86877	84983	88007	103581	116293
2004							79760	77656	80863	94818	107269

Table 6.3.1. Temperature categories and recruitment means ± SD for input to medium term projections of sprat stock development. The temperature categories were derived from the overall mean (3.7° C) and standard deviation (1.3° C) for the entire time series. Category means are derived from subsets of temperature data containing observations whose means equate to the overall mean or overall mean ± 1 SD. (N = 10, 7 and 8 per category.)

Temperature Category	Mean Temperature (°C)	Mean log R (10^9)	SD log R	Exp(mean log R) (10^9)
1	2.4	3.71	0.946	41.0
2	4.0	4.02	0.761	55.7
3	5.1	4.34	0.792	76.7

Table 6.3.2. F *status quo* (ICES 2002) compared to F precautionary (Fpa) and F0.1.

Species	F *status quo*	Fpa	F0.1
Cod	1.07	0.70	0.65
Herring	0.43	0.17	0.36
Sprat	0.32	0.40	1.18

Table 6.4.1. Estimates of F and Z reference points for different levels of natural mortality.

	Natural mortality rates					
Age	present	Low	low-medium	medium	medium-high	high
1	0.279	0.308	0.391	0.475	0.789	1.104
2	0.255	0.273	0.332	0.392	0.643	0.894
3	0.234	0.246	0.284	0.321	0.481	0.640
4	0.229	0.239	0.269	0.300	0.429	0.558
5	0.228	0.239	0.271	0.302	0.433	0.564
6	0.233	0.246	0.285	0.324	0.484	0.645
7	0.230	0.241	0.275	0.309	0.456	0.603
8	0.230	0.241	0.275	0.309	0.456	0.603
Mean(3-5)	0.230	0.241	0.275	0.308	0.448	0.587

Ref.point	Natural mortality					
	present	low	low-medium	medium	medium-high	high
F0.1	0.42	0.45	0.52	0.61	1.2	2.47
Flow	0	0	0	0	0	0
Fmed	0.43	0.39	0.3	0.21	0	0
Fhigh	1.28	1.23	1.07	0.92	0.39	0
F35%SPR	0.37	0.39	0.44	0.5	0.75	1.01
Floss	1.25	1.2	1.04	0.89	0.37	0
Z0.1	0.65	0.69	0.8	0.92	1.65	3.06
Zlow						
Zmed	0.66	0.64	0.57	0.52		
Zhigh	1.51	1.47	1.34	1.23	0.84	
Z35%SPR	0.6	0.63	0.72	0.81	1.2	1.6
Zloss	1.49	1.44	1.32	1.2	0.82	0.59

Table 6.4.2. Total mortality referencepoints of sprat at various levels of natural mortality, weight at age and exploitation pattern derived as averages for the periods 1979-1983, 1986-1990 and 1991-1999.

Ref. point	1991-1999	1986-1990	1979-1983
F0.1	0.41	0.49	1.72
Flow	0	0	0
Fmed	0.57	0.53	0
Fhigh	1.64	1.9	0.29
F35%SPR	0.4	0.6	0.88
Floss	1.6	1.86	0.27
Z0.1	0.65	0.8	2.31
Zlow			
Zmed	0.81	0.84	
Zhigh	1.88	2.21	0.87
Z35%SPR	0.64	0.91	1.47
Zloss	1.84	2.17	0.85

Table 6.4.3. Estimates of status quo fishing mortality (year^{-1}), SSB and virgin SSB ('000 tonnes) produced by the three models.

Model	Status quo F			Status quo SSB			Virgin SSB		
	Cod age 4-7	Herring age 3-6	Sprat age 3-7	Cod	Herring	Sprat	Cod	Herring	Sprat
VPA	0.67	0.27	0.32	221	970	628	687	1929	1137
MSVPA				233	1610	939	632	1006	839
MSGVPA				330	1510	826	705	1096	818

Table 6.4.4. Effort multipliers for which the highest value of the total landings (a) and the highest resource rent (b) of the Baltic fishery is obtained. Cod is assumed to be ten times more valuable than herring and sprat, and costs in (b) to be directly proportional to effort.

a)

Fishery	VPA	MSVPA	MSGVPA
Cod	0.70	1.15	1.86
Herring and Sprat	1.26	1.63	1.82
Total value (arbitrary units)	1720	2047	2300

b)

Fishery	Single species	MSVPA	MSGVPA
Cod	0.42	0.45	0.45
Herring and Sprat	0.47	0.03	0.10
Total value (arbitrary units)	1401	1264	1371

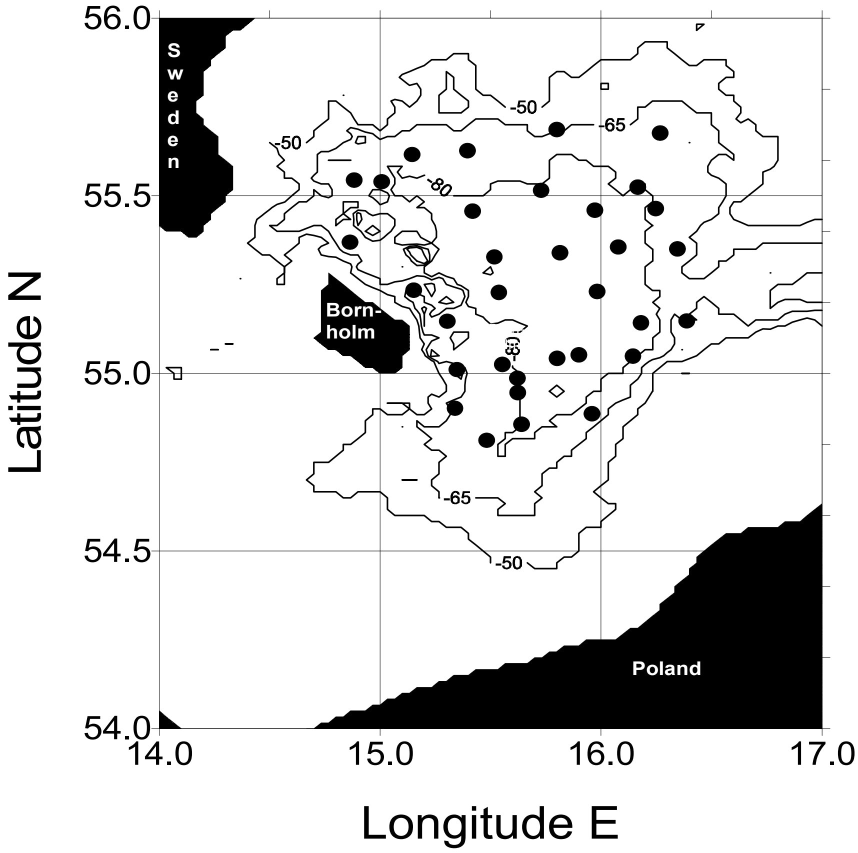

Fig. 1.1.1. Sampling stations in July 1999, CTD and trawl. At each CTD station up to three trawl hauls were made.

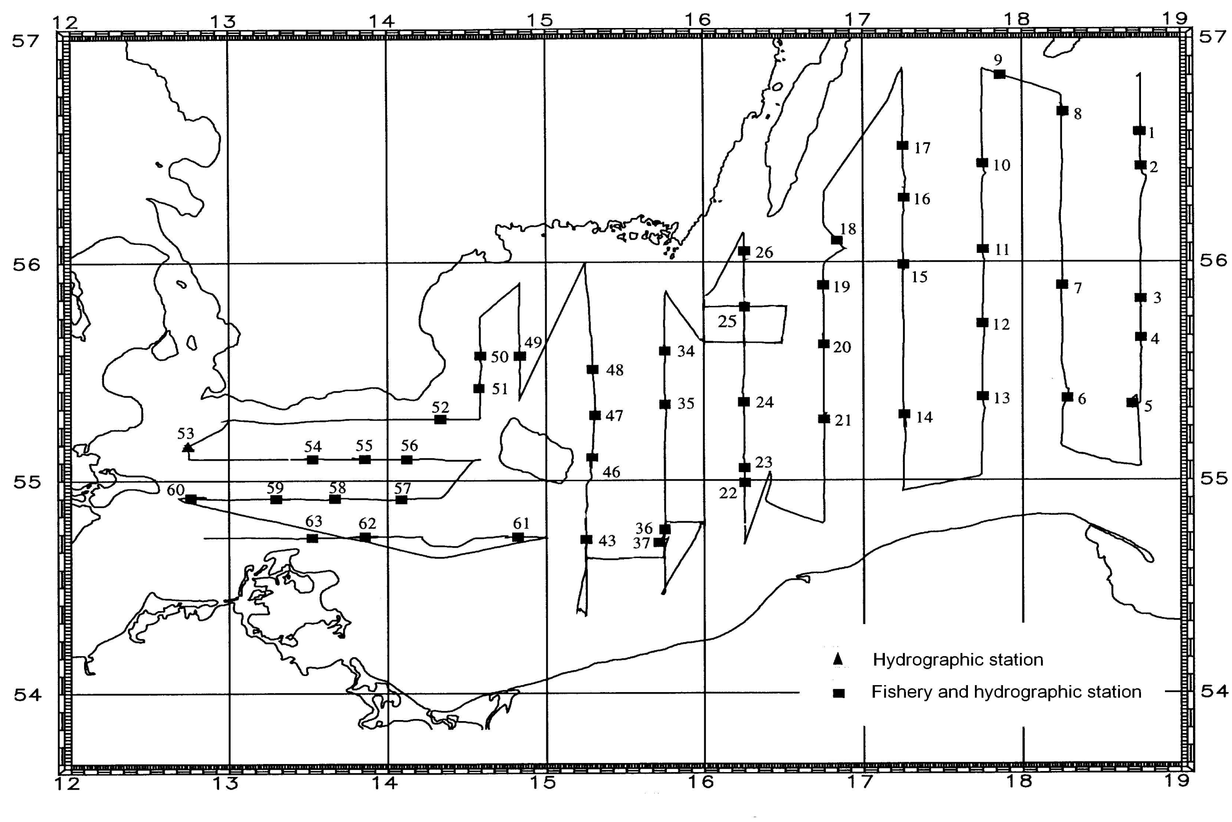

Fig. 1.1.2. Cruise track and trawl positions RV "Walther Herwig III" in May/June 1999.

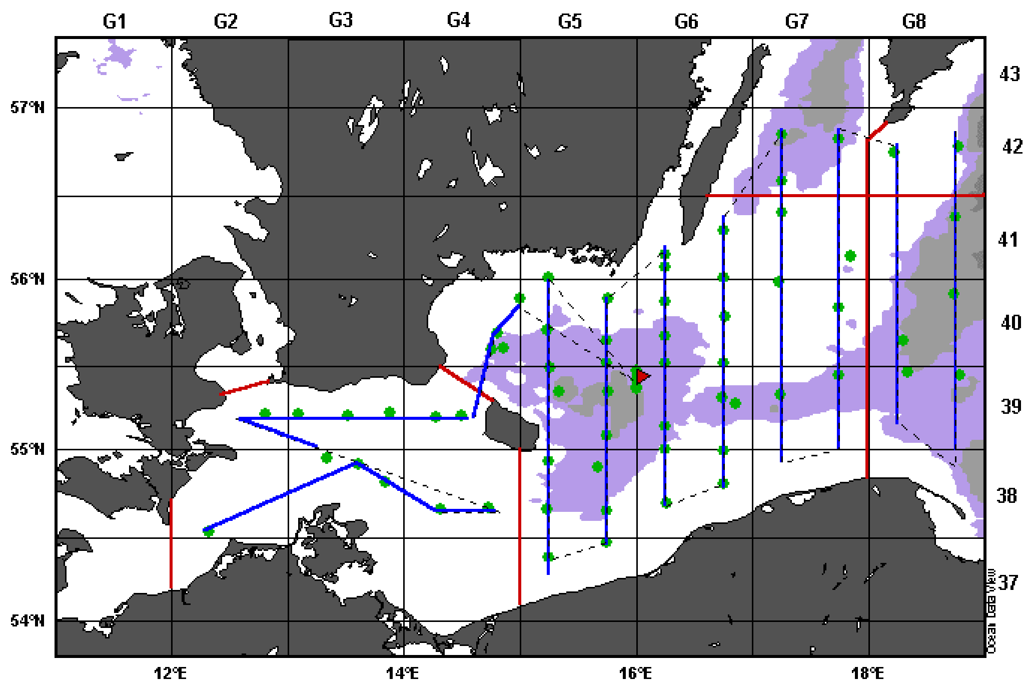

Fig. 1.1.3. Cruise track (dotted) with the hydroacoustic transsects (solid) and sampling stations of the Cruise No. 228b RV "W.Herwig III" in May/June 2001. The triangel indicates the area of the day/night investigations with RV “Alkor”.

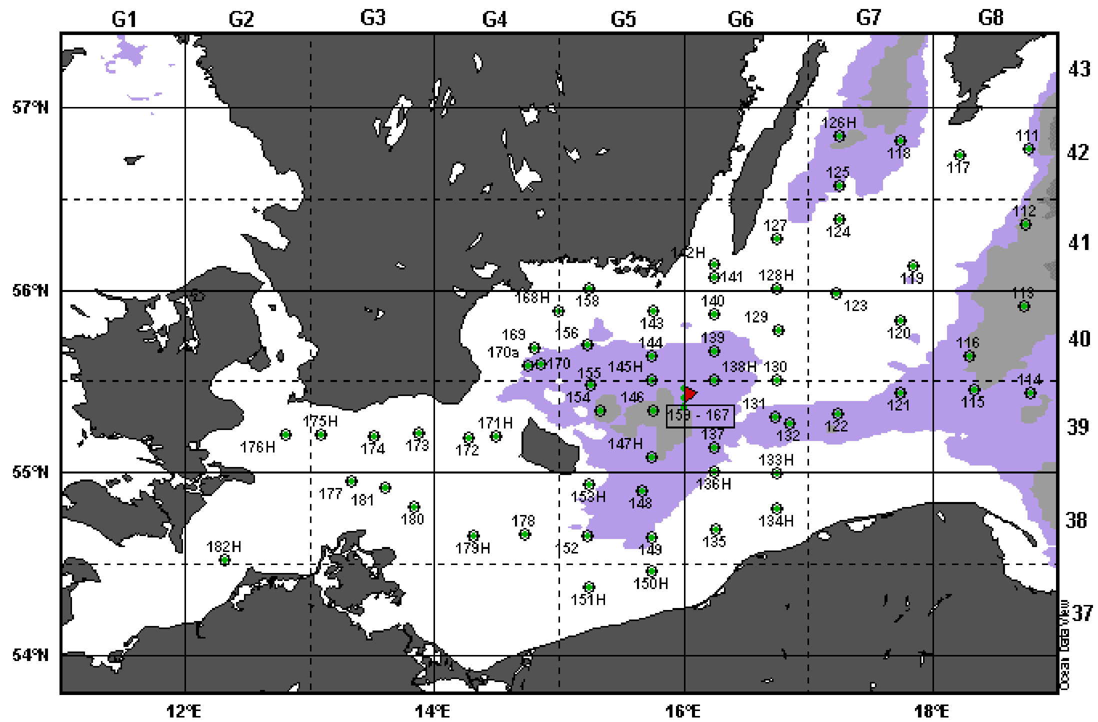

Fig. 1.1.4. Sampling stations (trawling and hydrography , stations marked by a “H” only hydrography) of the Cruise No. 228b RV "W.Herwig III" in May/June 2001”. The triangel indicates the area of the day/night investigations with RV “Alkor”.

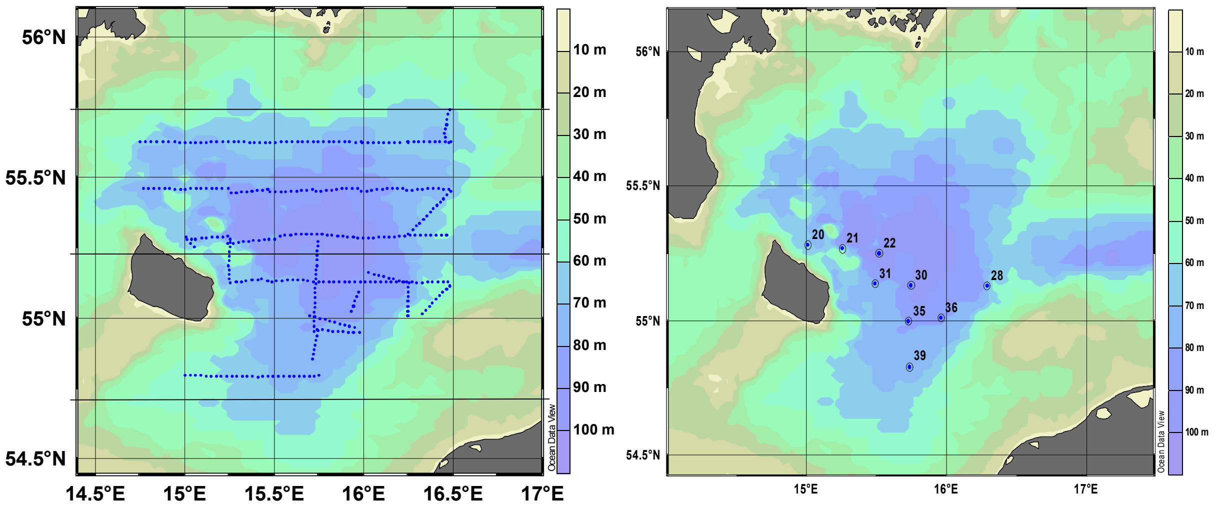

Fig. 1.1.5. Hydoacoustic survey August 2001: hydroacoustic transects and positions of trawling stations

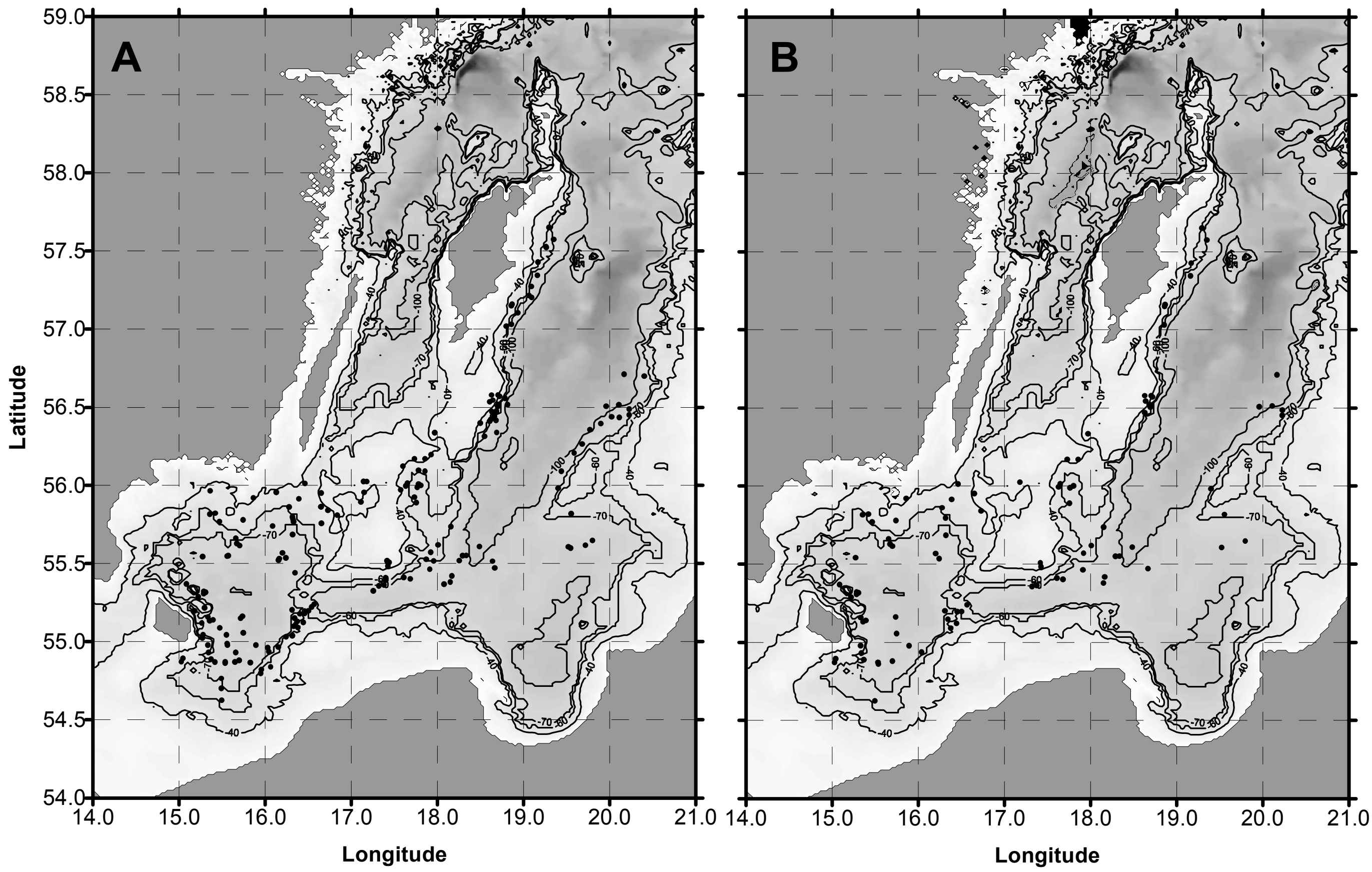

Fig.1.1.6. Survey stations over bathymetry in 1994-99 (A), and 1998/99 (B). The data were distributed in three sub-areas of the Eastern Baltic Sea to account for the gradient in salinity at depth. The areas were Bornholm Basin (15<Longitude E<17), Slupsk Furrow (17<Longitude E<18 and 54.5<Latitude N<56.5), and Southern Gotland Basin (18<Longitude E<22 and 55.5<Latitude N<58.0). Longitudinal and latitudinal data are presented in decimal notation.

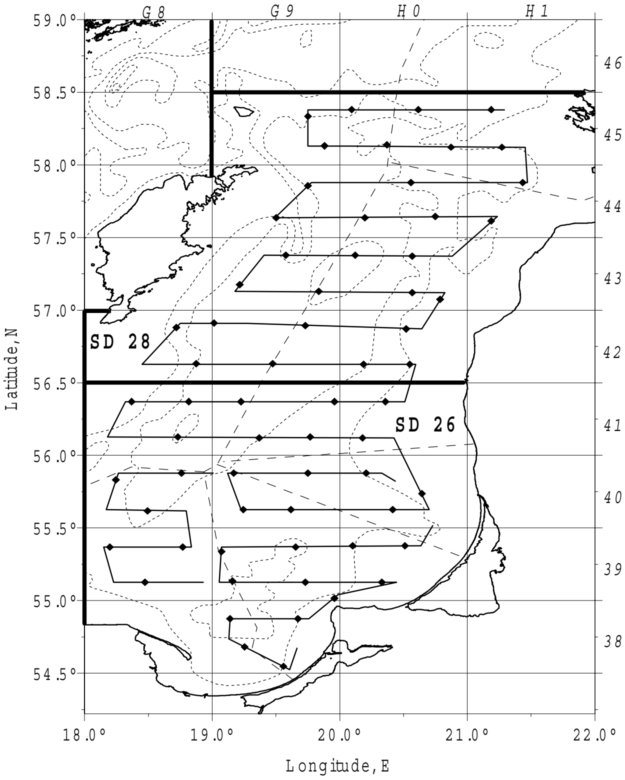

Fig. 1.1.7. The principal scheme of cruise track and trawl stations for joint Russian-Latvian hydroacoustic surveys in the Eastern Baltic Sea.

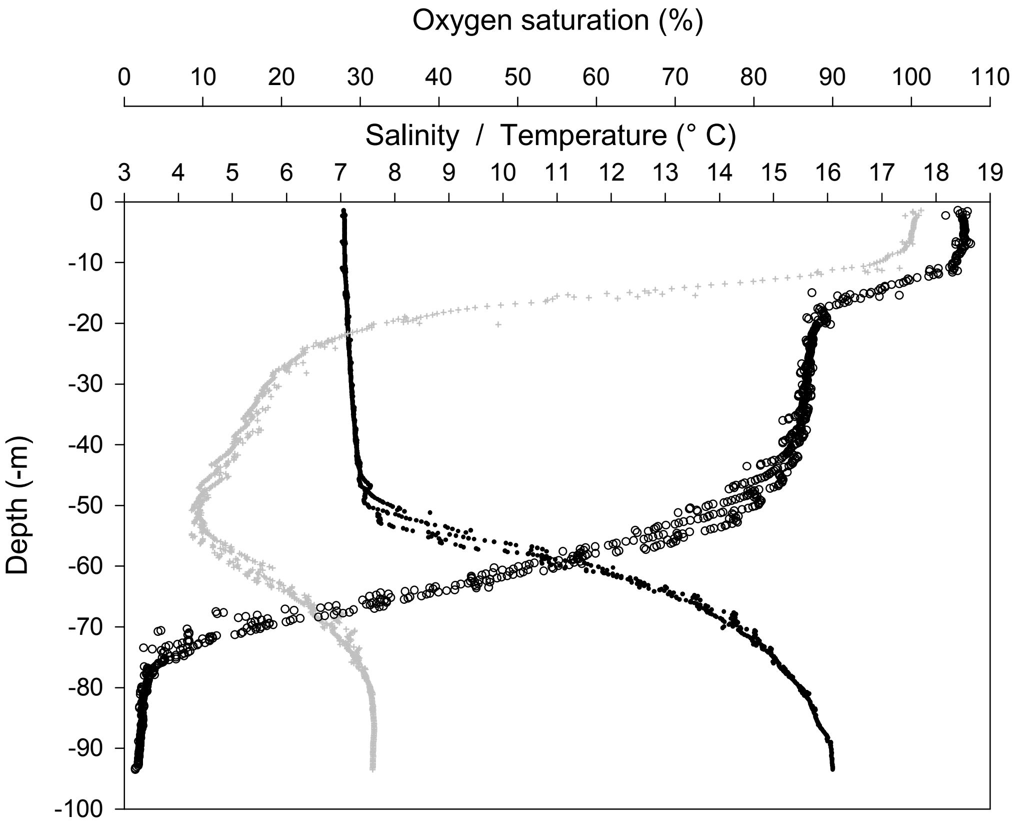

Fig. 1.1.8. Average vertical profiles of oxygen saturation (○), salinity (+) and temperature (+) in the study area during the cruise.

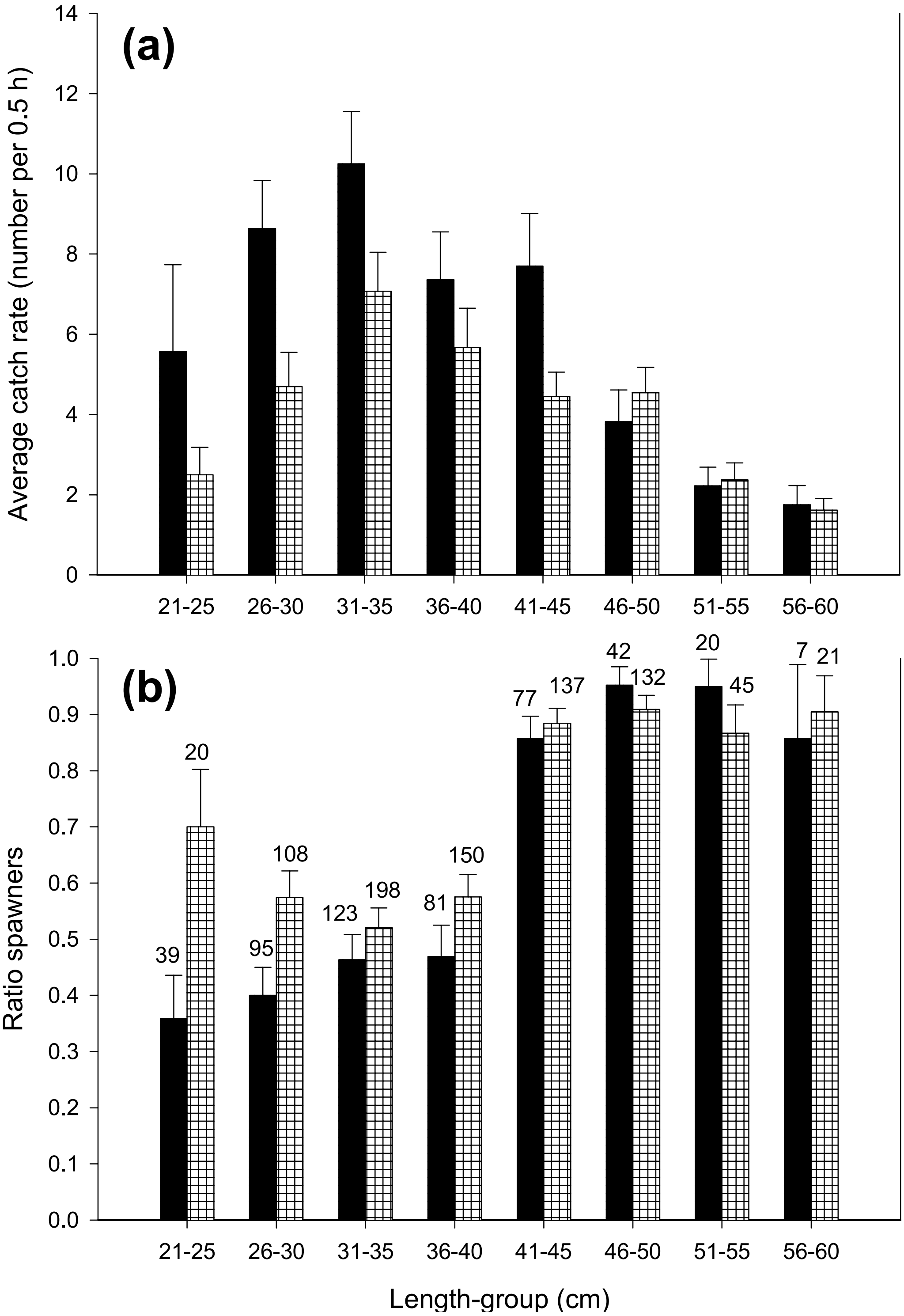

Fig. 1.1.9. Mean + S.E. catch rates (a) and ratio of spawners (b) per Baltic cod length group in demersal (black) and pelagic (squares) trawl hauls. Numbers per length group are given above each bar.

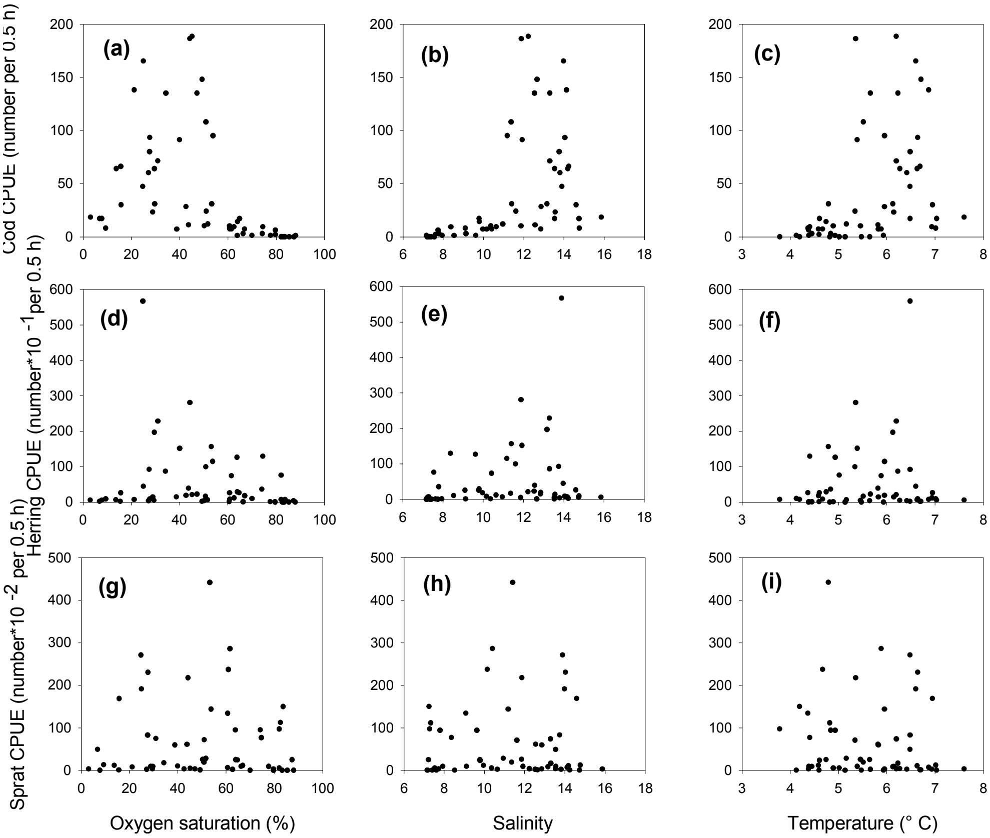

Fig. 1.1.10. Scatter plots of catch rates and oxygen saturation, salinity, and temperature for Baltic cod (a), (b), (c), herring (d), (e), (f) and sprat (g), (h), (i). Note the 10-fold scaling increase from Baltic cod to herring and from herring to sprat.

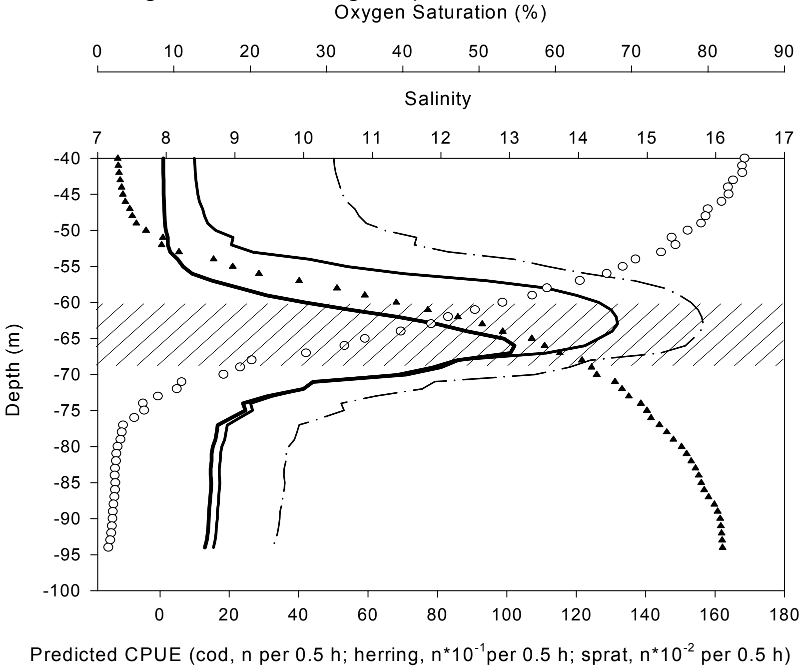

Fig. 1.1.11. Predicted vertical distributions of Baltic cod (━), herring (━), and sprat (-) in relation to vertical profiles of salinity (▲) and oxygen saturation (○). The hatched area indicates the vertical limits where cod eggs can both float and survive.

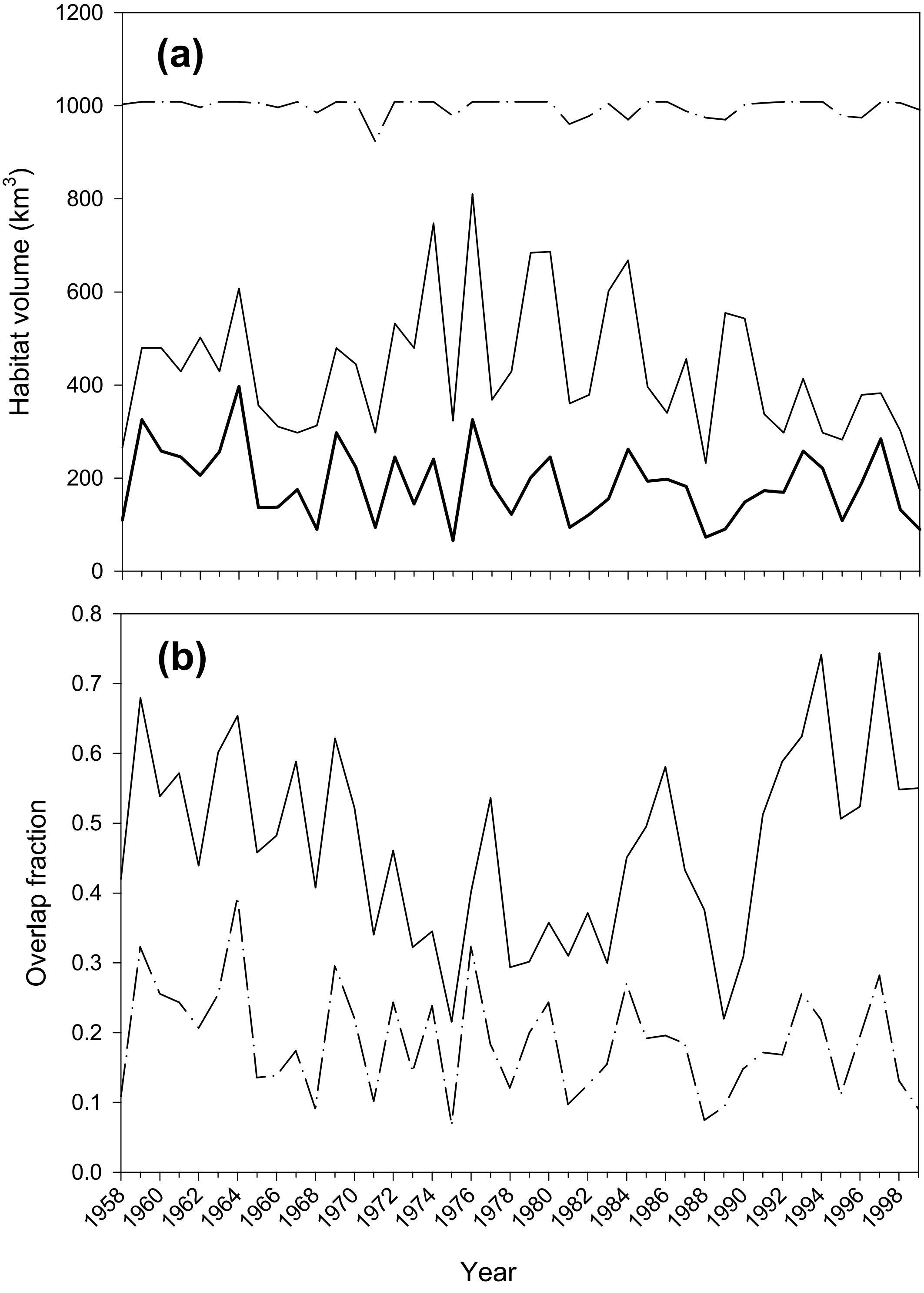

Fig. 1.1.12. Time series of (a) habitat volumes of Baltic cod (**-**), herring (**-**) and sprat (-), and (b) the fractions of the herring and sprat habitats where Baltic cod occurred.

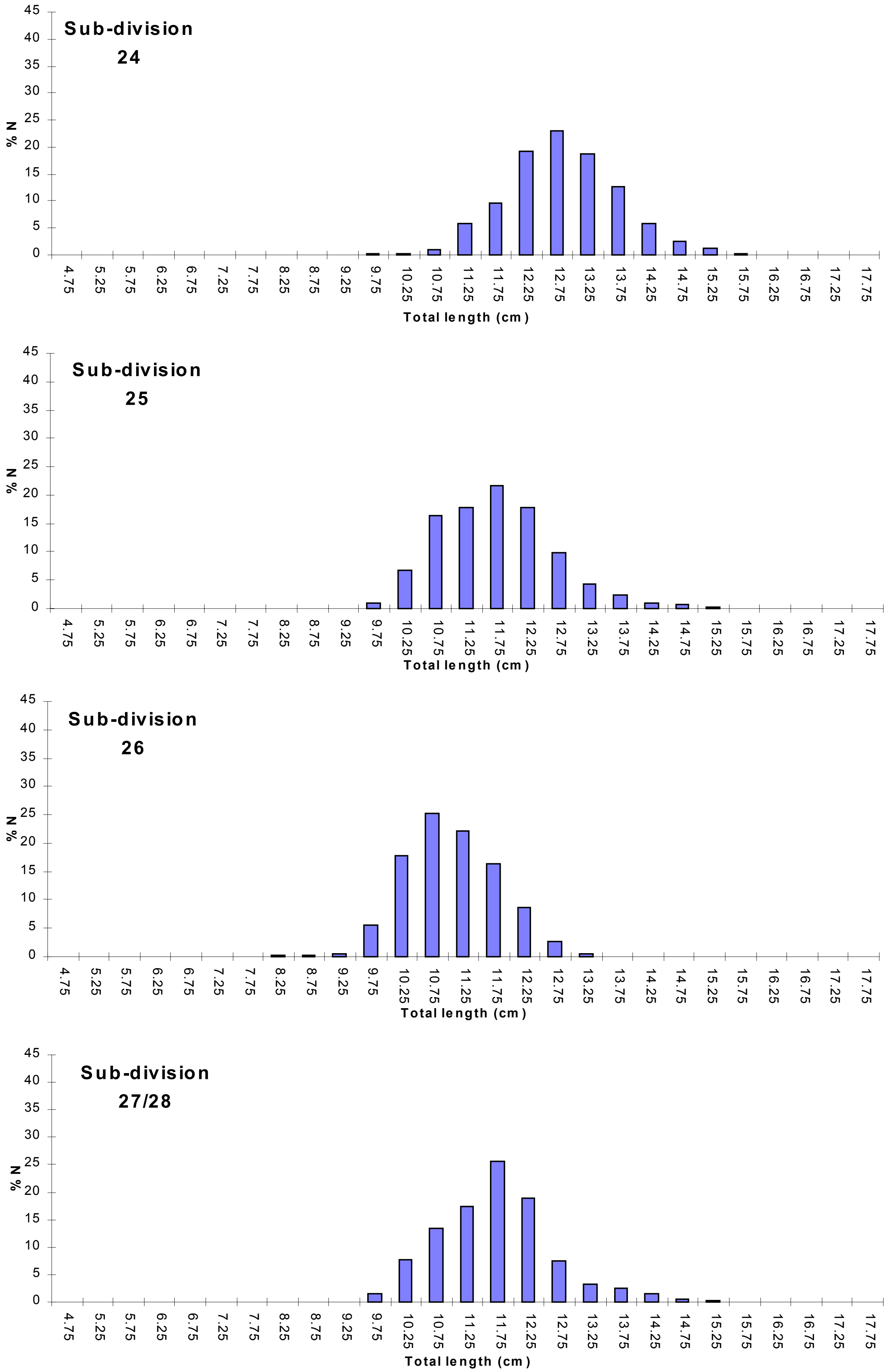

Fig. 1.1.13. Length distribution of sprat in Sub-divisions 24, 25, 26 and 27/28 in May/June 1999.

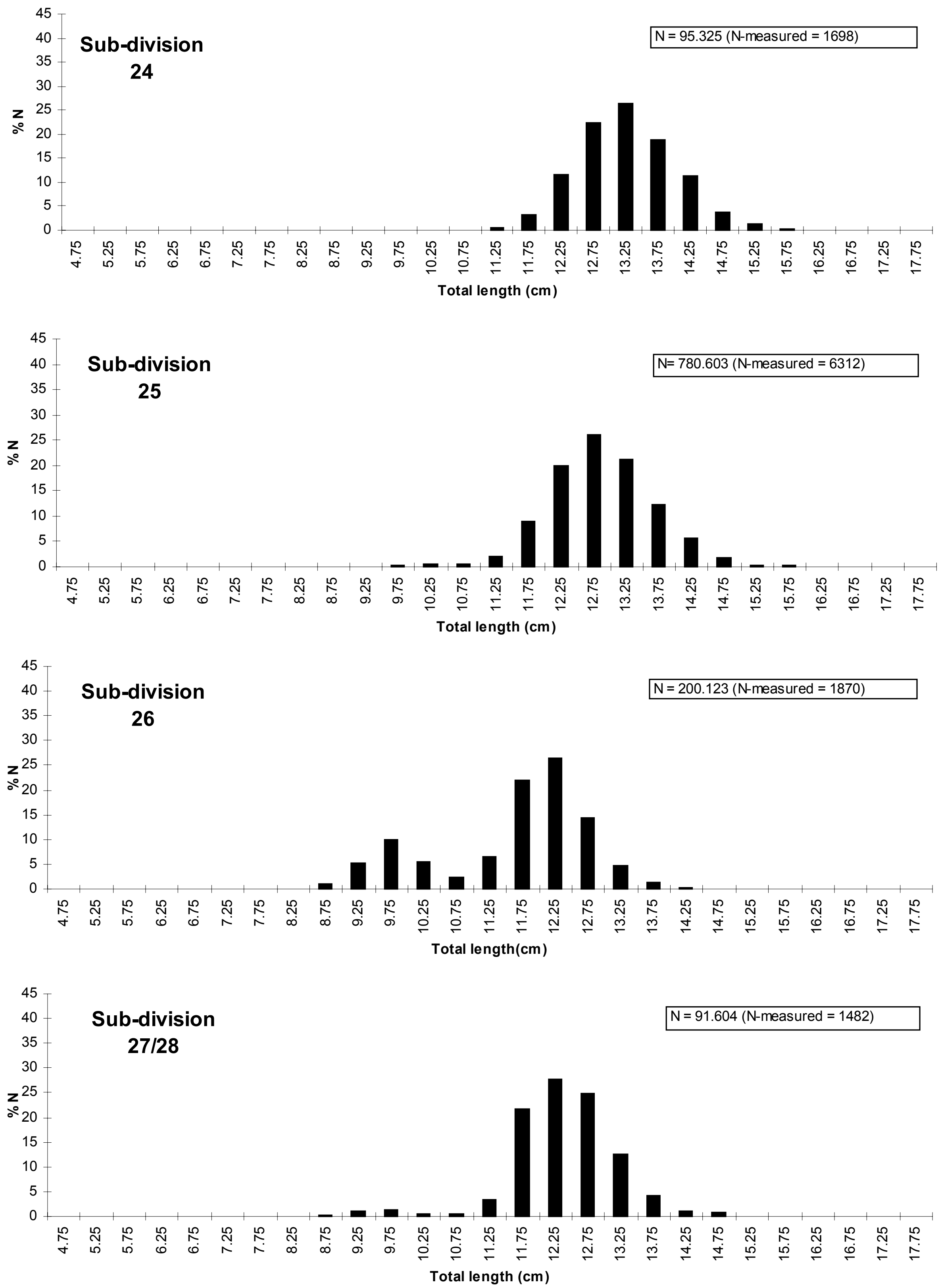

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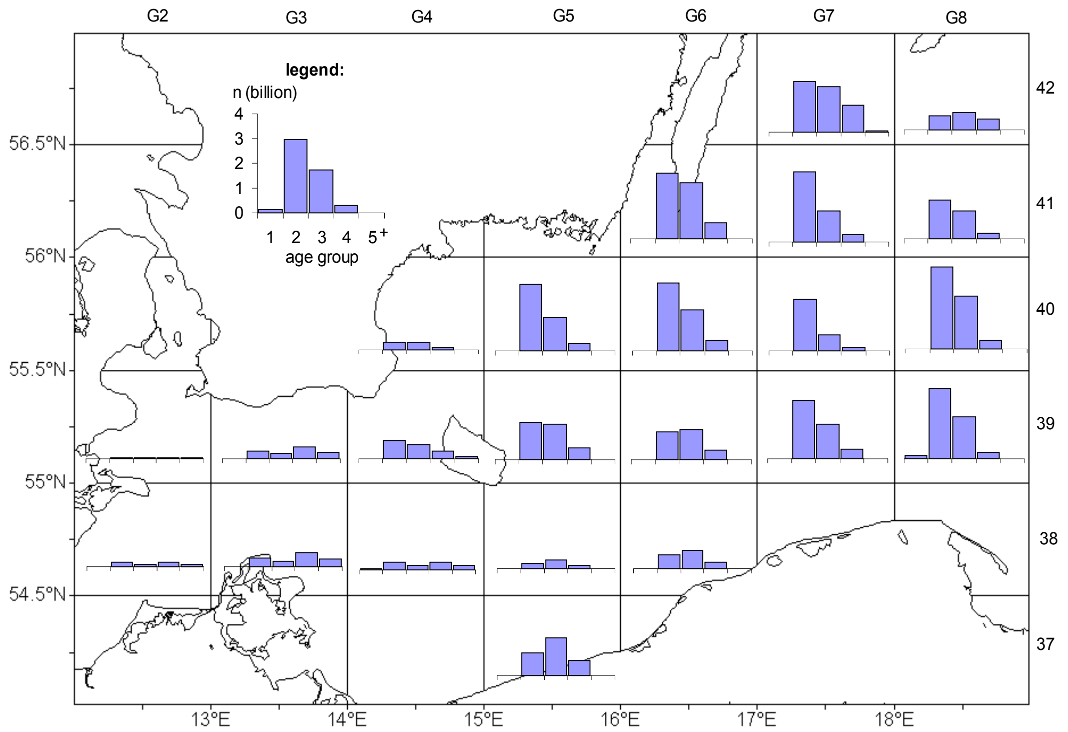
Fig. 1.1.14. Length distribution of sprat in Sub-divisions 24, 25, 26, and 27/28 (Cruise No. 228b RV "W.Herwig III" in May/June 2001).

a)



b)

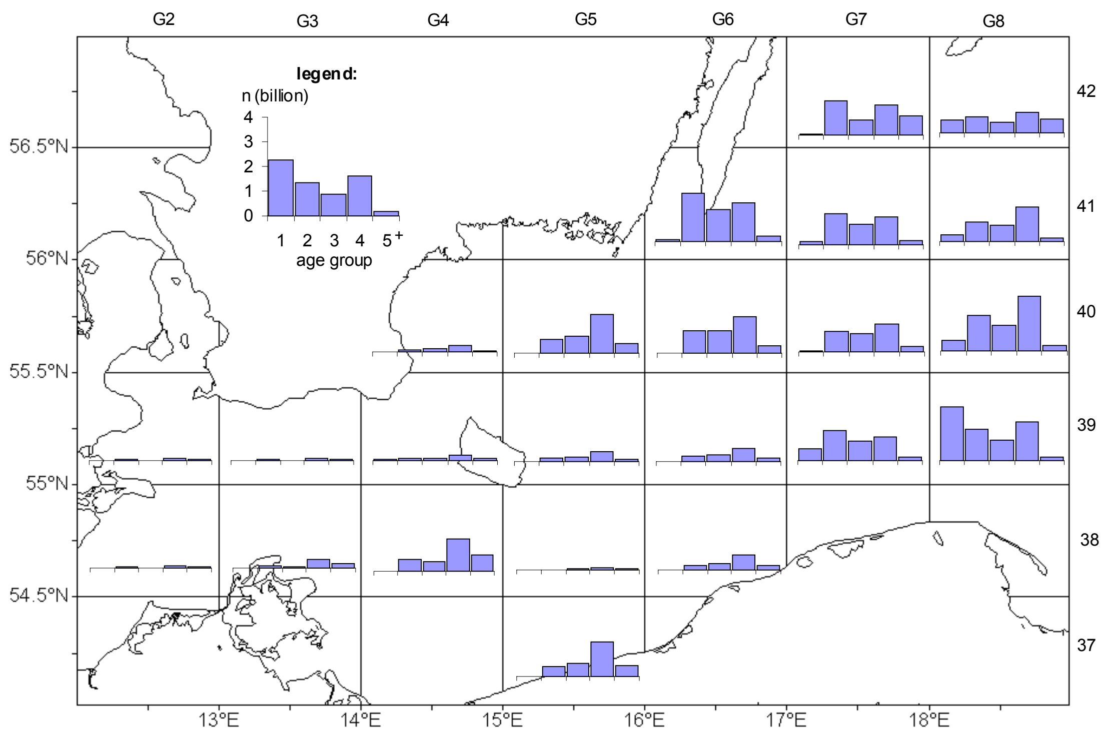
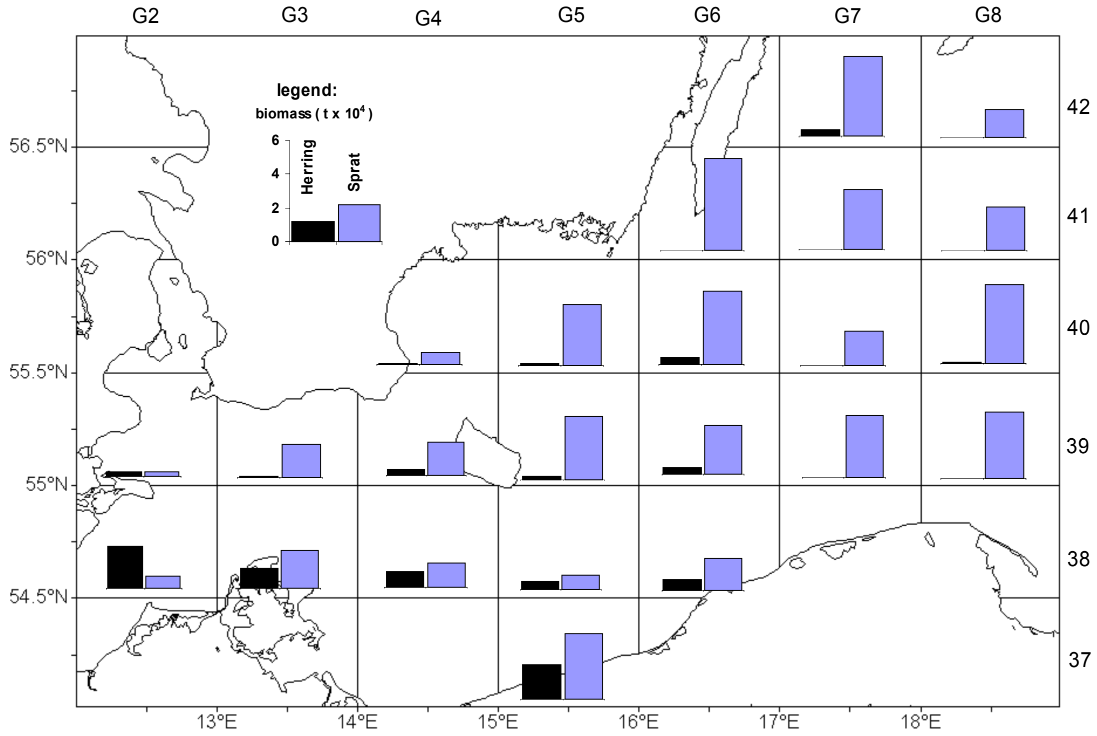


Fig. 1.1.15. Sprat number per age group (billion), (a) May/June 1999; b) May/June 2001)

a)



b)

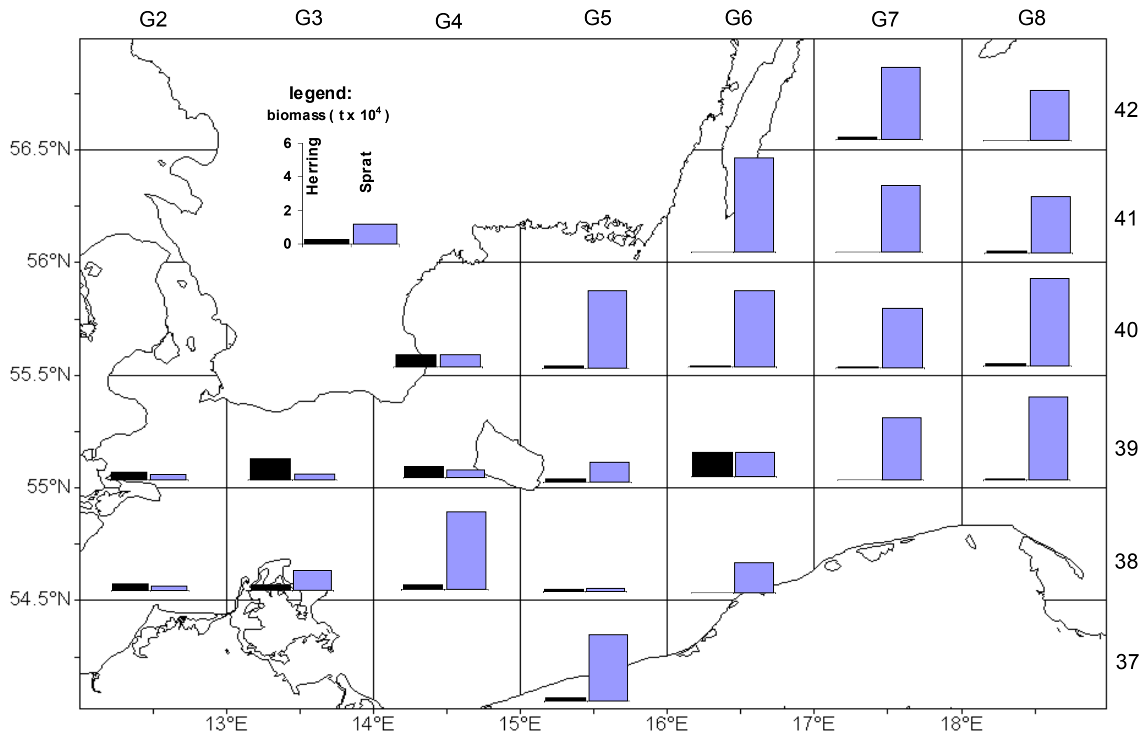


Fig 1.1.16. Herring and sprat biomass ('0000 t) per rectangle (a) May/June 1999; b) May/June 2001)

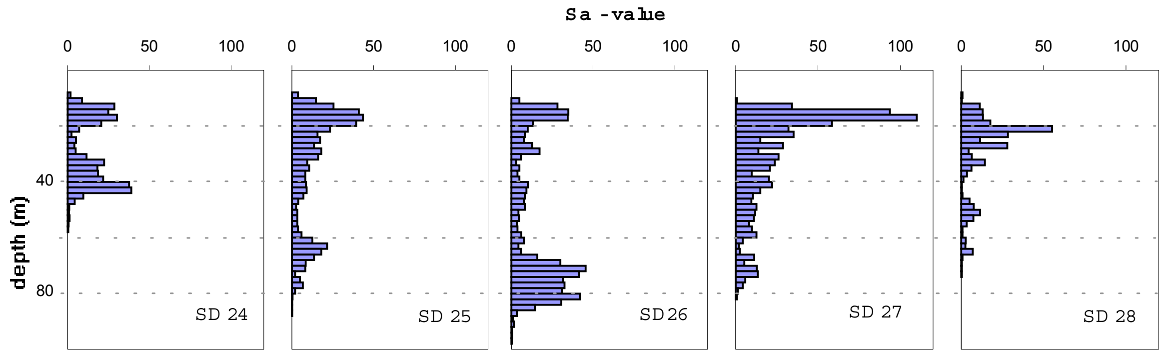


Fig. 1.1.17. Vertical distribution of the mean Sa-values per Sub-division in May/June 1999.

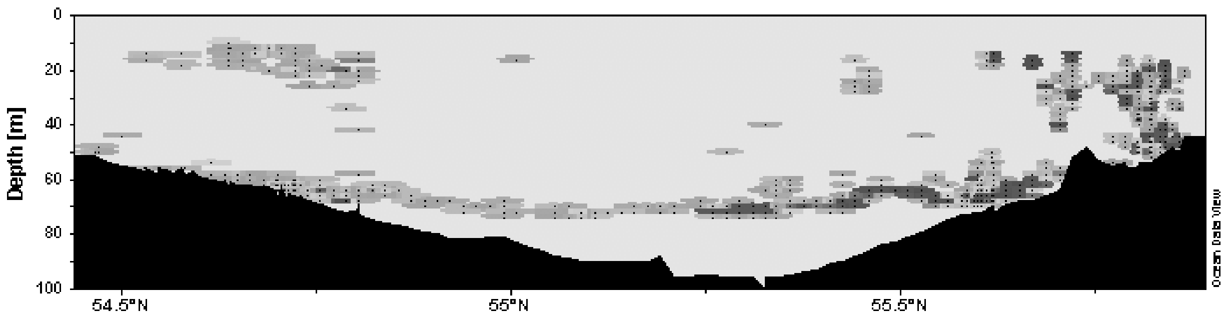


Fig. 1.1.18. Vertical distribution of Sprat on a transsect along 15.7°E from south to north across the Bornholm Basin in May/June 1999.

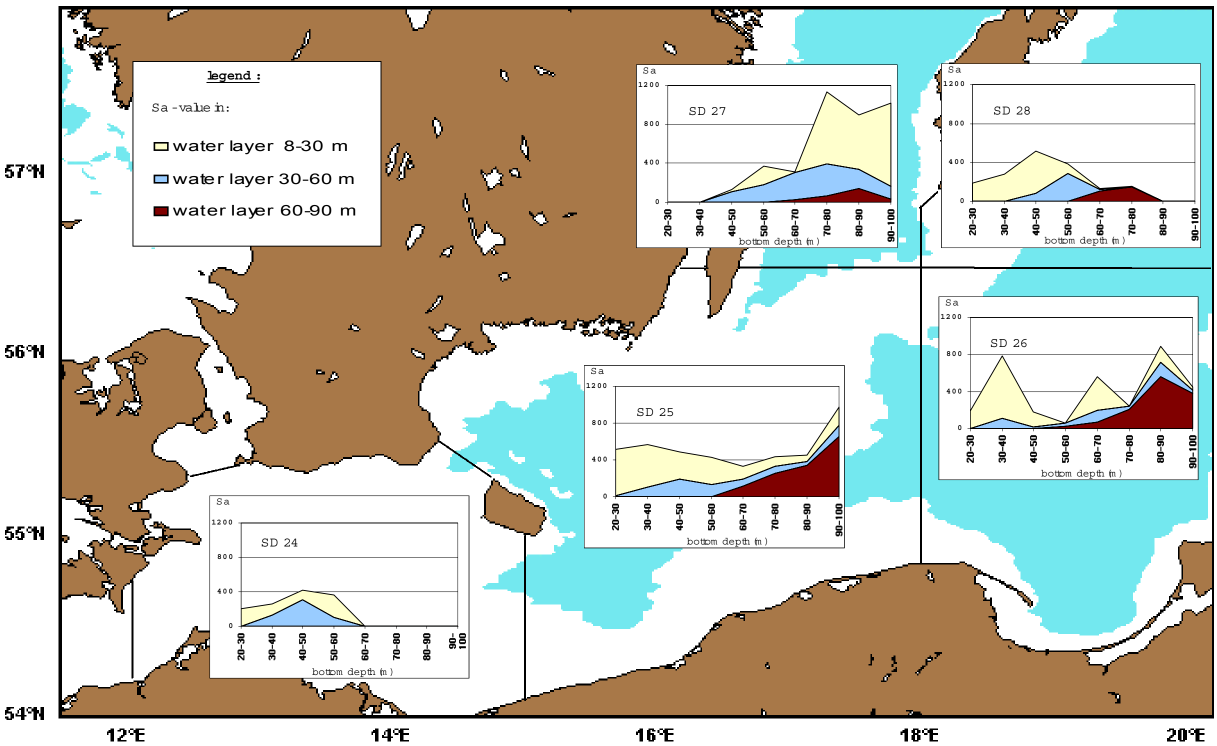


Fig. 1.1.19. Mean Sa-values in the water layers 8 – 30m, >30 – 60m and > 60 – 90m in relation to bottom depth per Sub-division in May/June 1999.

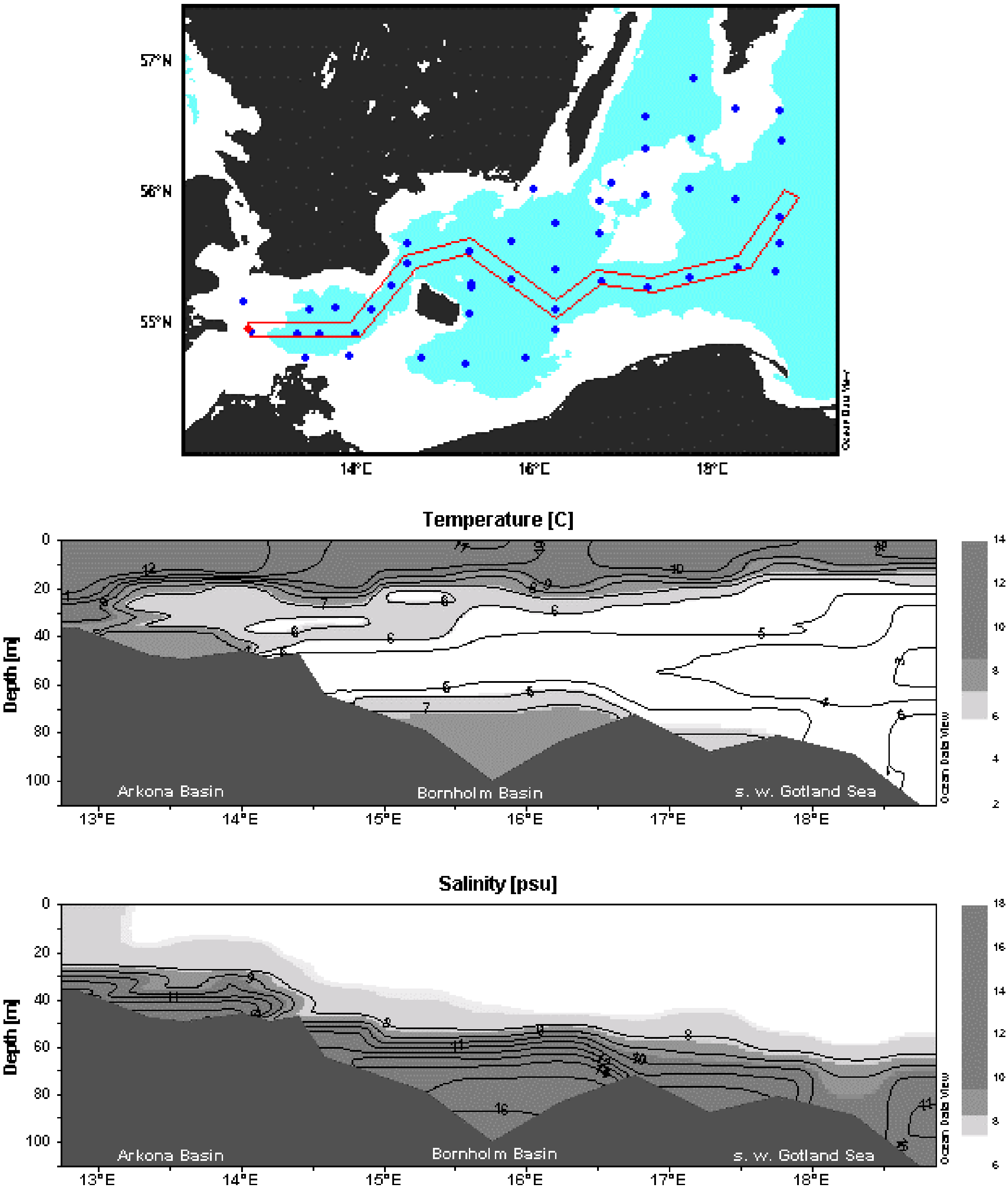


Fig. 1.1.20. Vertical contour plots of temperature and salinity from stations on a transect across the investigated area (RV „Walther Herwig III“ in May/June 1999).

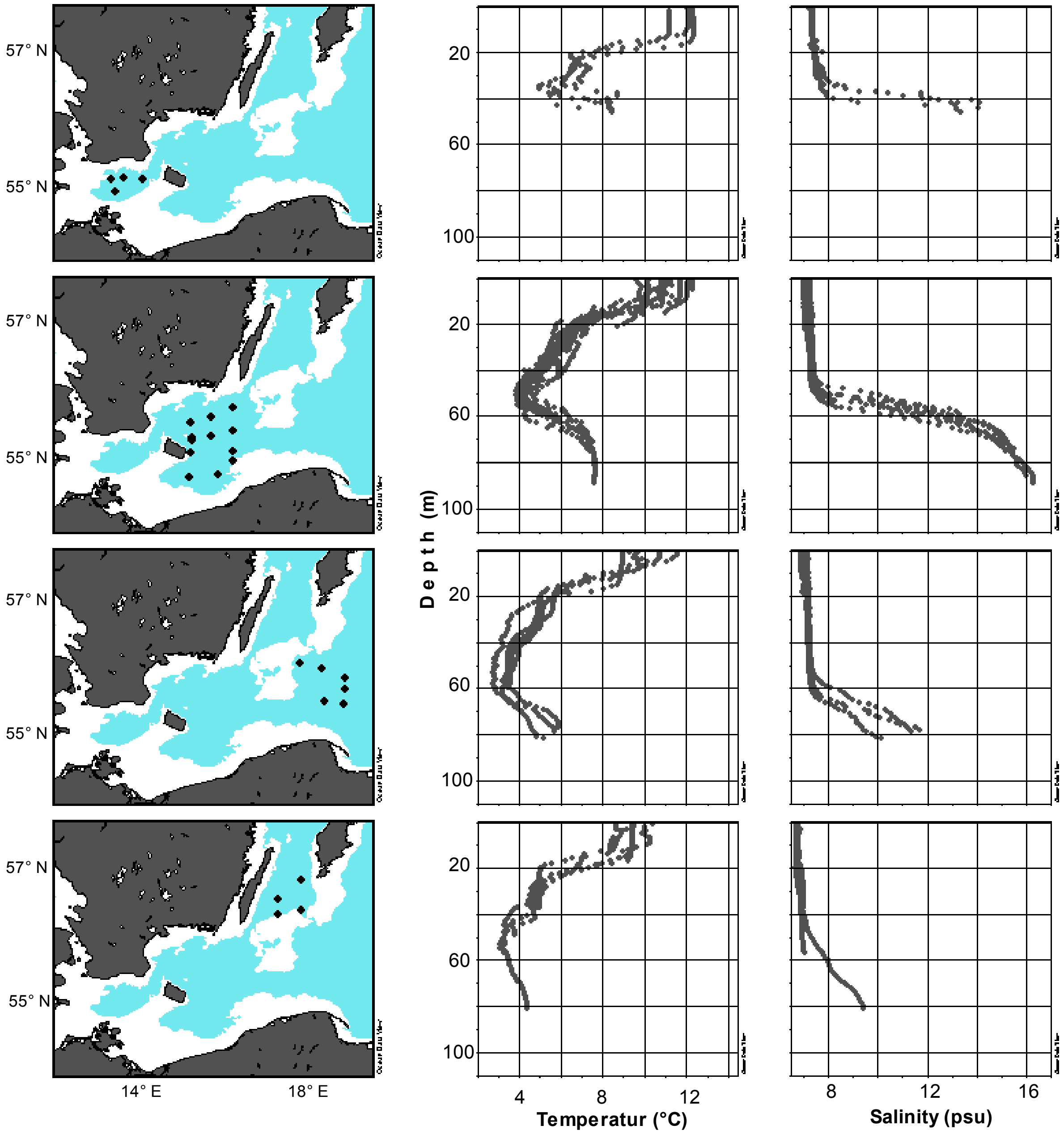


Fig.1.1.21. Scatter plots of temperature and salinity on selected stations in the Arkona- and Bornholm Basin as well as in the s. w. Gotland and Aland Sea (RV „Walther Herwig III“ in May/June 1999).

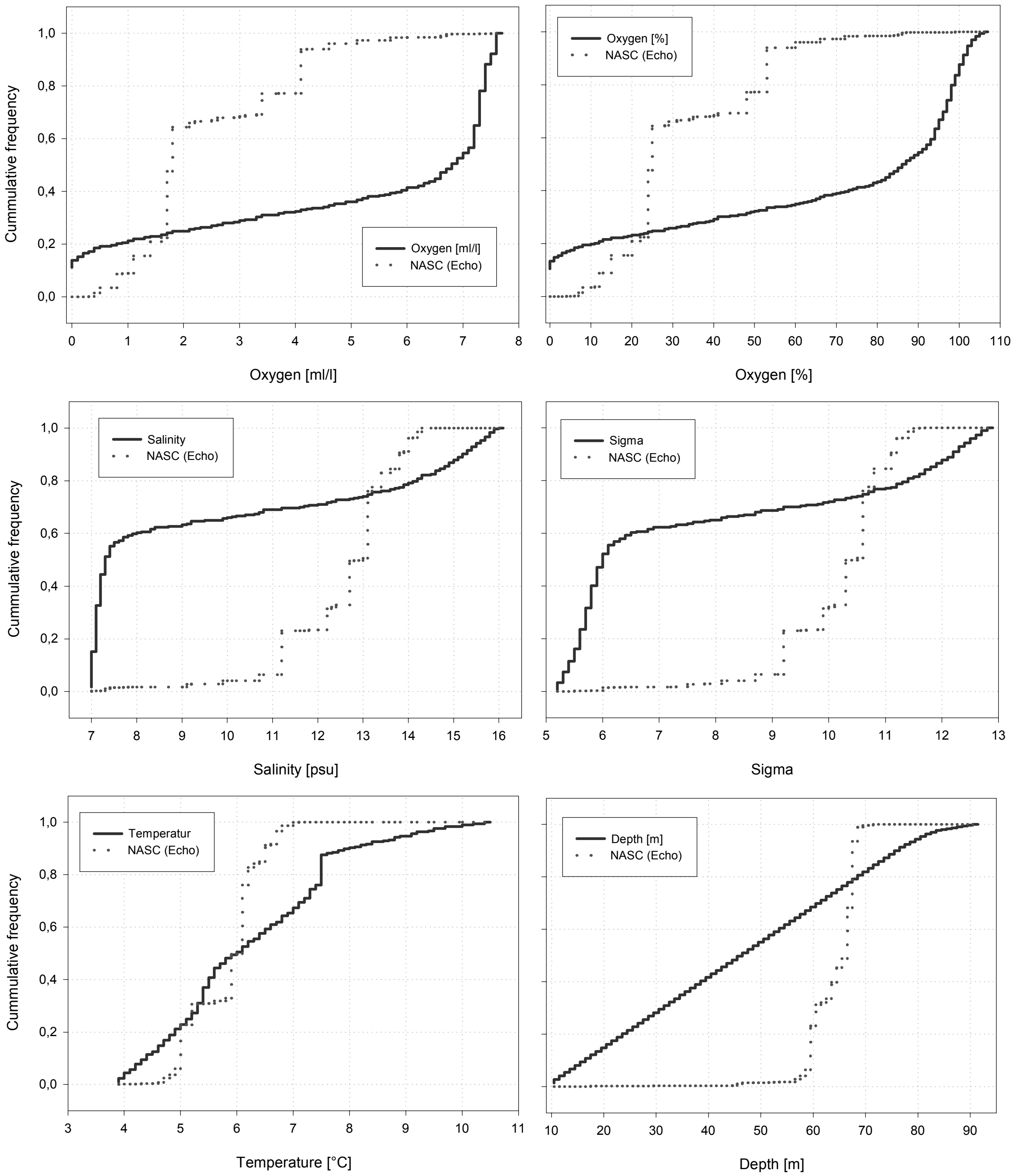


Fig. 1.1.22. Cumulative frequency distribution plots describing the hydrographic factors influencing the vertical distribution of sprat in May/June 1999

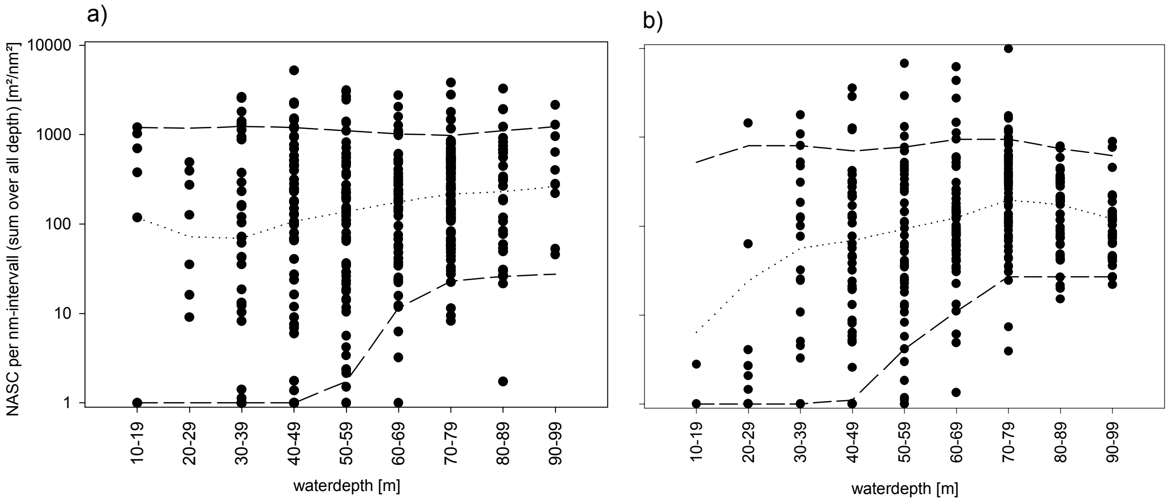


Fig. 1.1.23. Charactarization of patchiness of fish-distribution in 1999 and 2001 at a basin-wide, horizontal scale. The overall backscaterring values of every 1nm-transect unit was plotted against waterdepth.

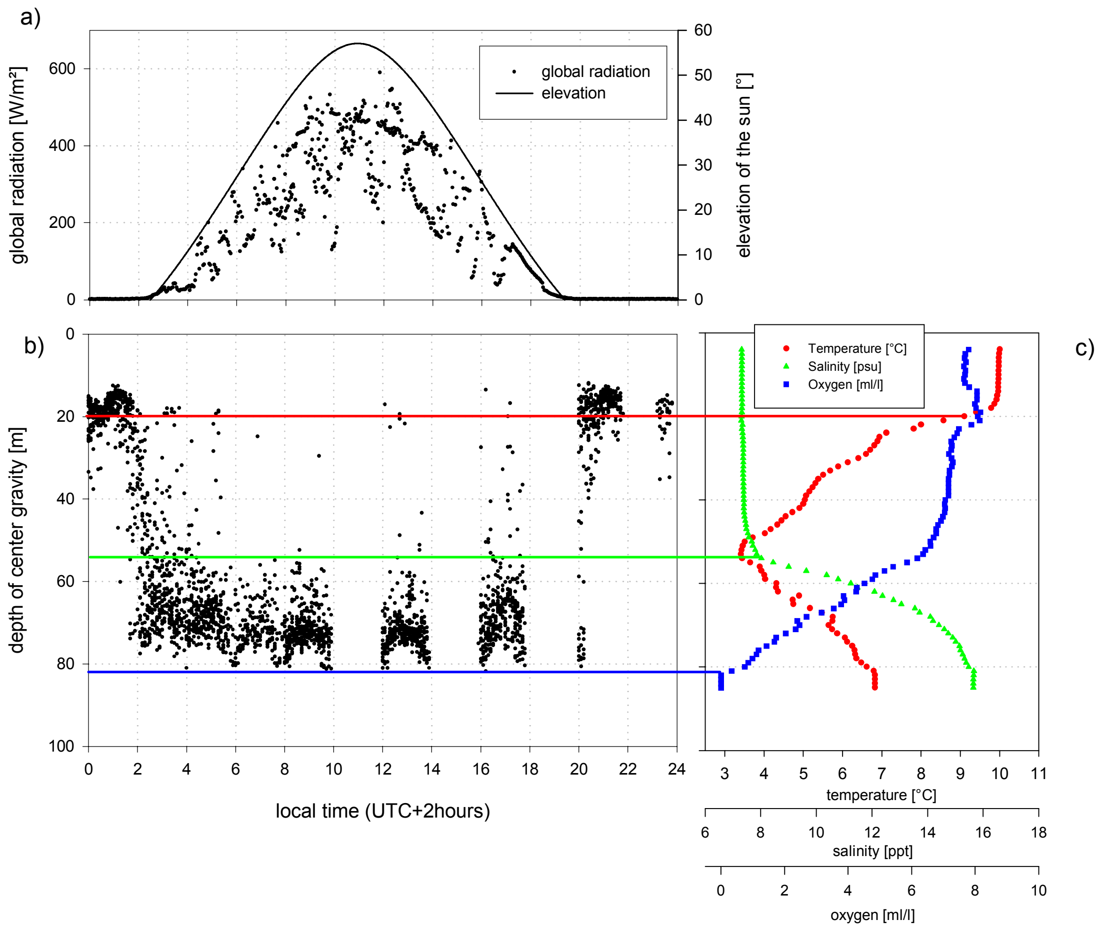


Fig. 1.1.24. Vertical distribution of pelagic and daily vertical migration in reation to hydrographic parameters and elevation of the sun in June 2001. Data were derived from hydroacoustic data used for calculation of the center depth of gravity of echostrength.

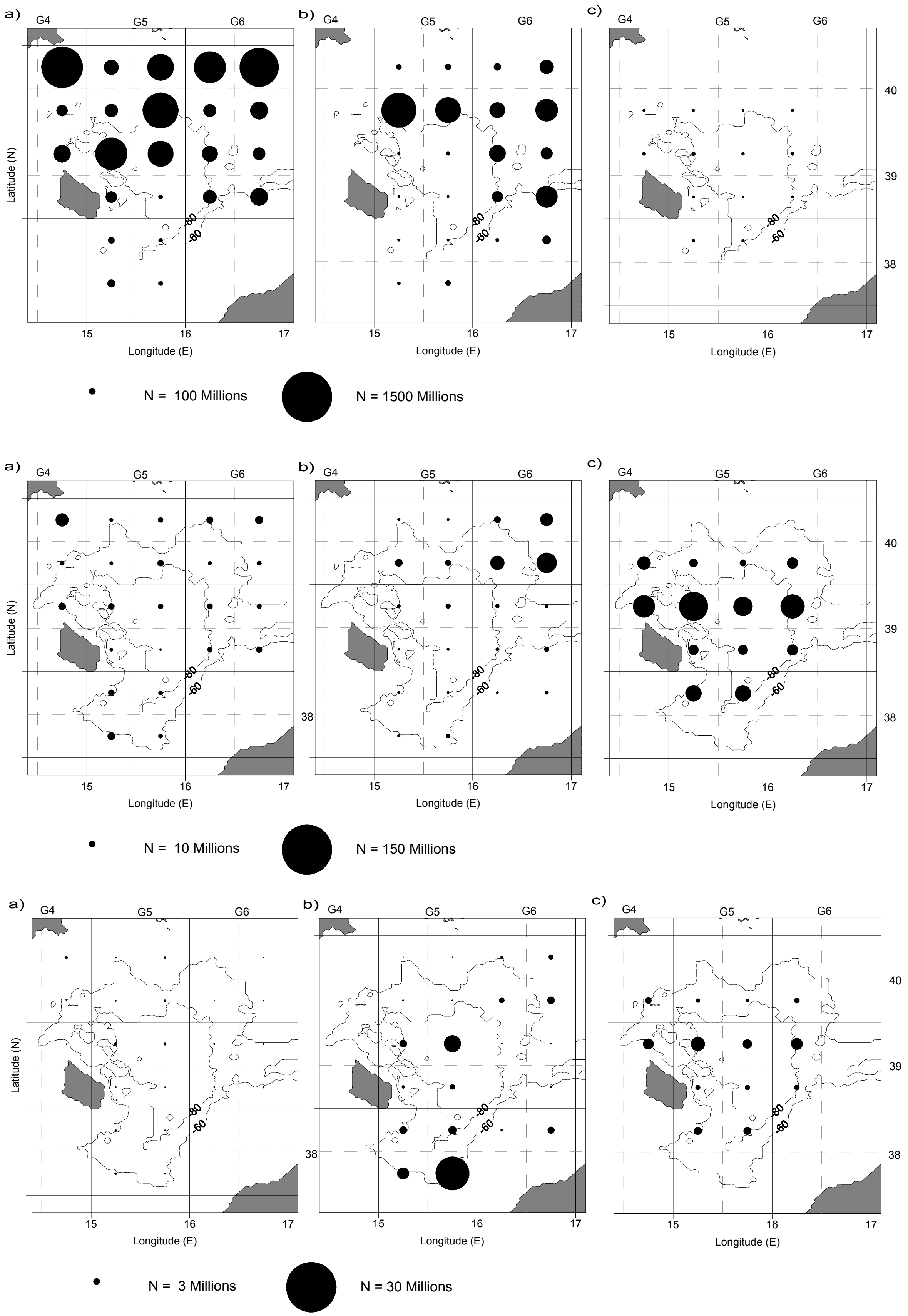


Fig. 1.1.25. Mesoscale distribition (numbers per quarters of ICES-rectangle) of pelagic fishes in the Bornholm Basin as estimated from three hydroacoustic surveys (for each row: a) May/June 1999; b) May/June 2001; c) August 2001). Rows: upper - Sprat; medium - Herring; lower – Cod.

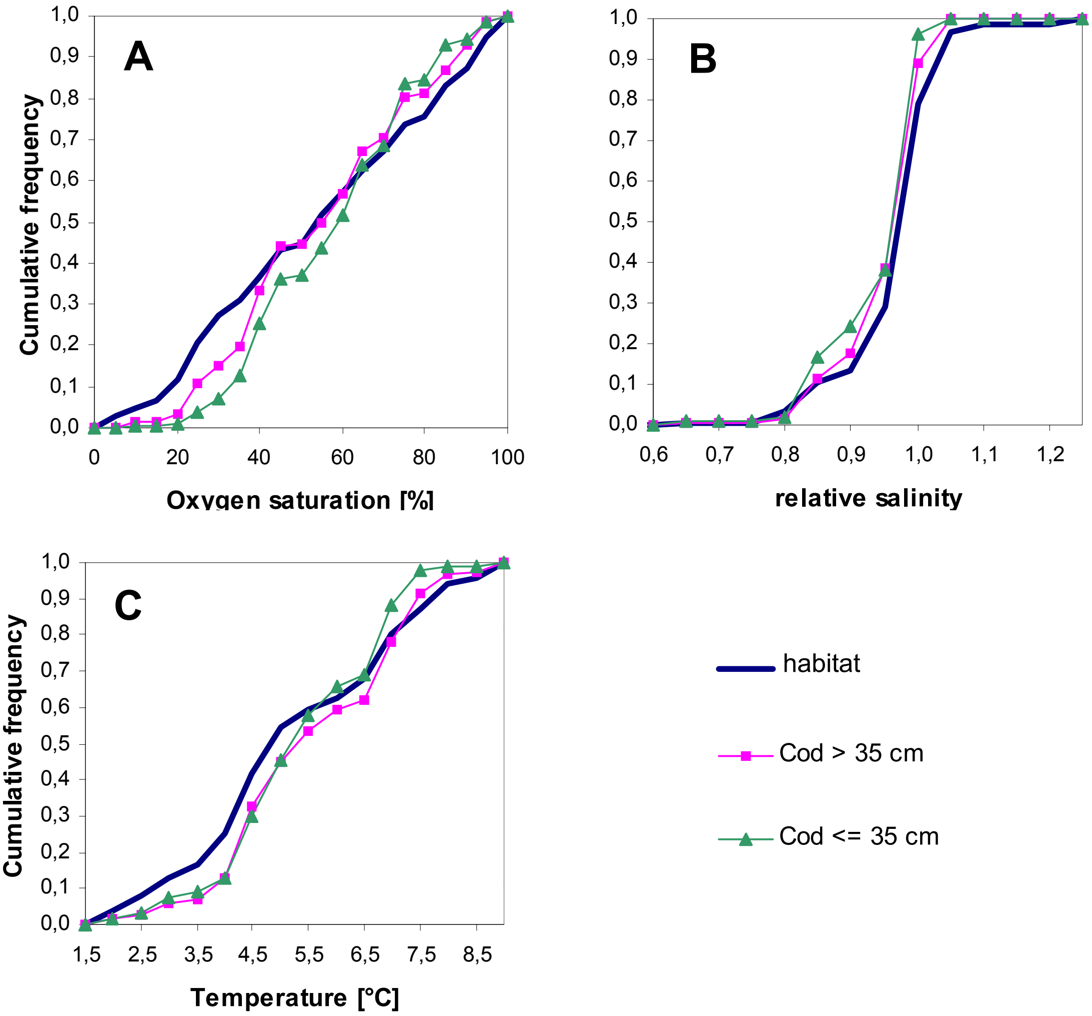


Fig. 1.1.26. Cumulative frequency distributions of cod CPUE in relation to oxygen saturation (A), salinity (B) and temperature (C) in the Bornholm Basin in 1998/99. The plot of f(x) for each habitat variable is in bold and indicated as 'habitat'.

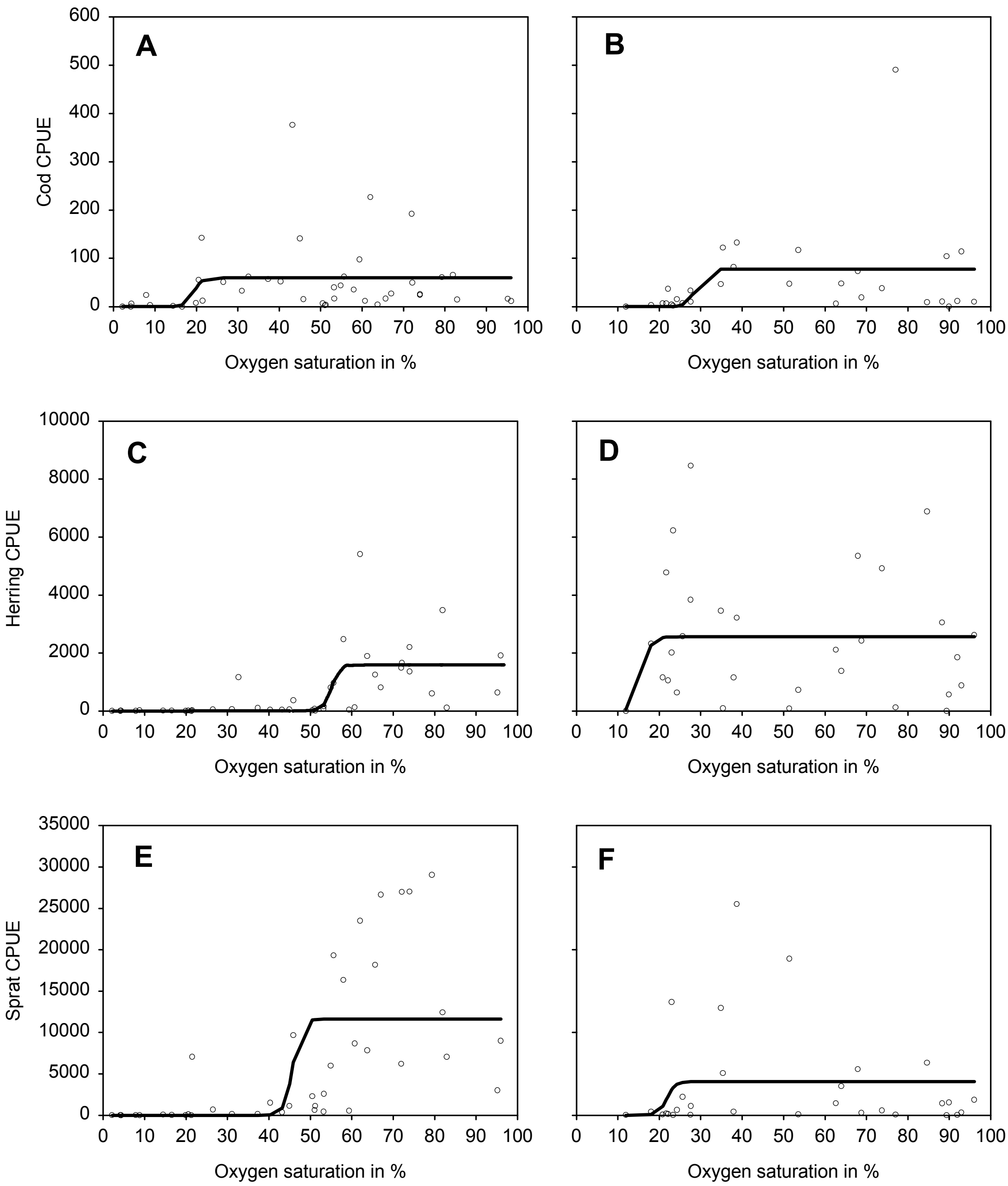


Fig.1.1.27. CPUE in relation to oxygen saturation. Bornholm cod (A), Gotland cod (B), Bornholm herring (C), Gotland Herring (D), Bornholm sprat (E) and Gotalnd sprat (F).

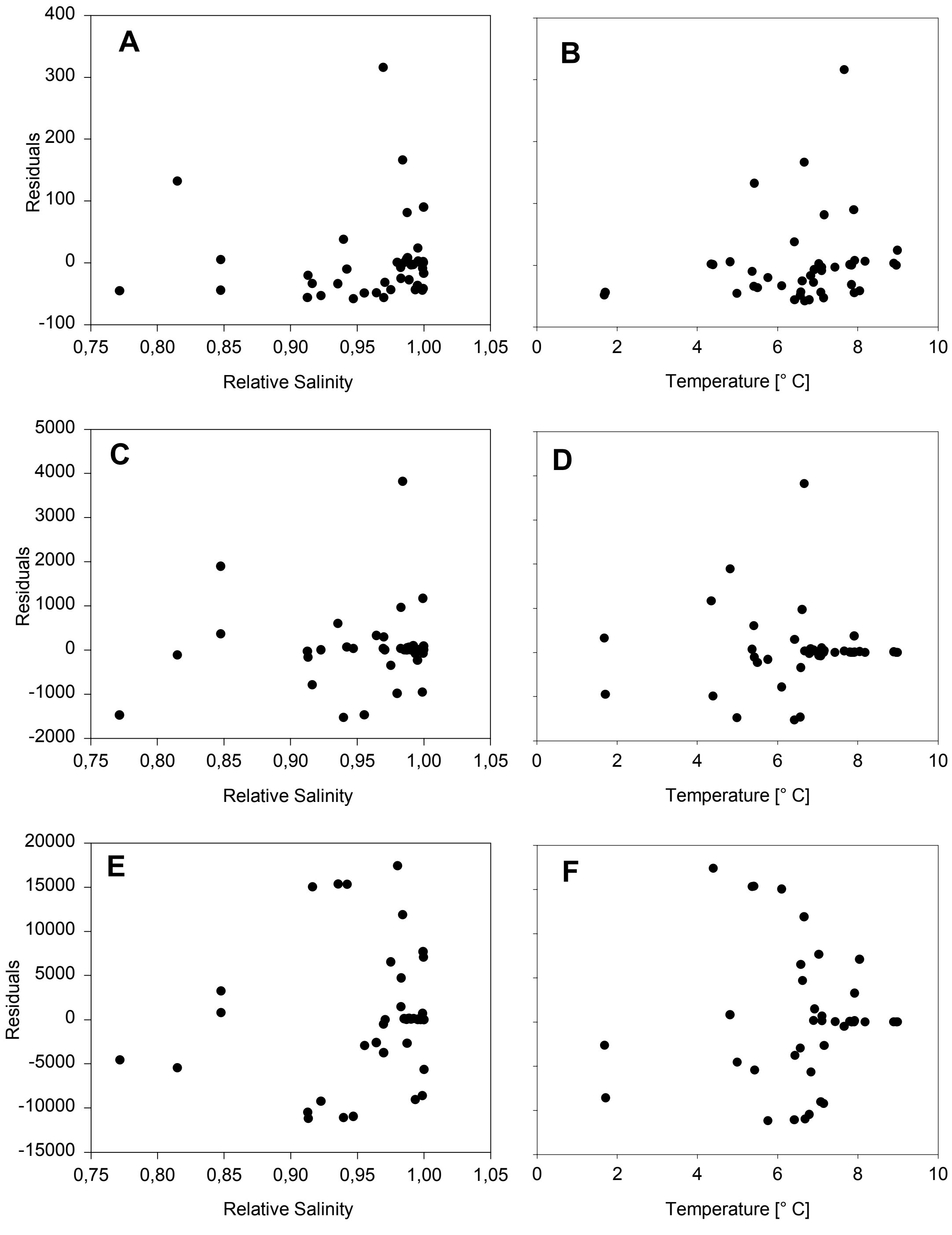


Fig. 1.1.28. Bornholm Basin. Residuals from the regression of CPUE versus oxygen saturation in relation to relative salinity and temperature for cod (A and B), herring(C and D) and sprat (E and F).

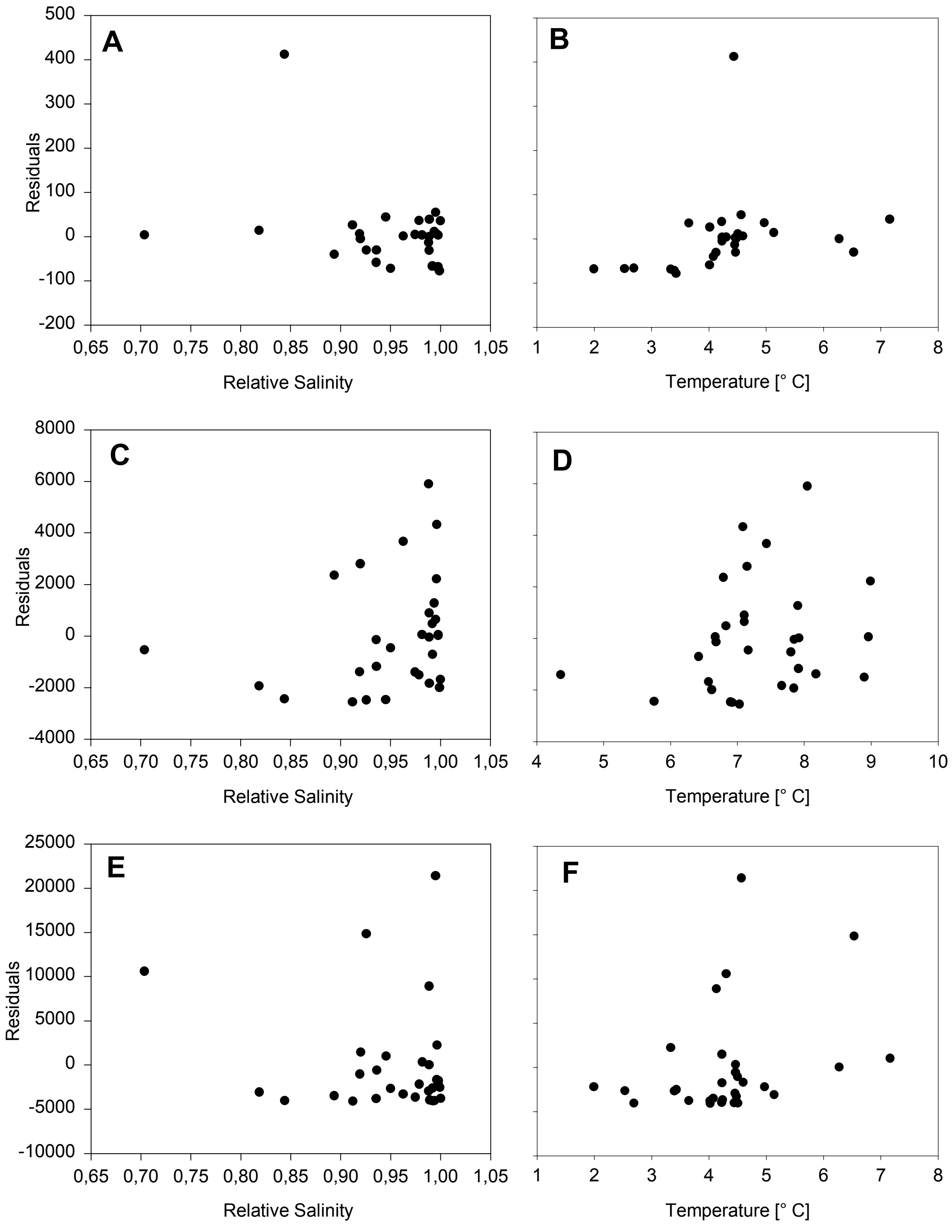


Fig. 1.1.29. Gotland Basin. Residuals from the regression of CPUE versus oxygen saturation in relation to relative salinity and temperature for cod (A and B), herring(C and D) and sprat (E and F).

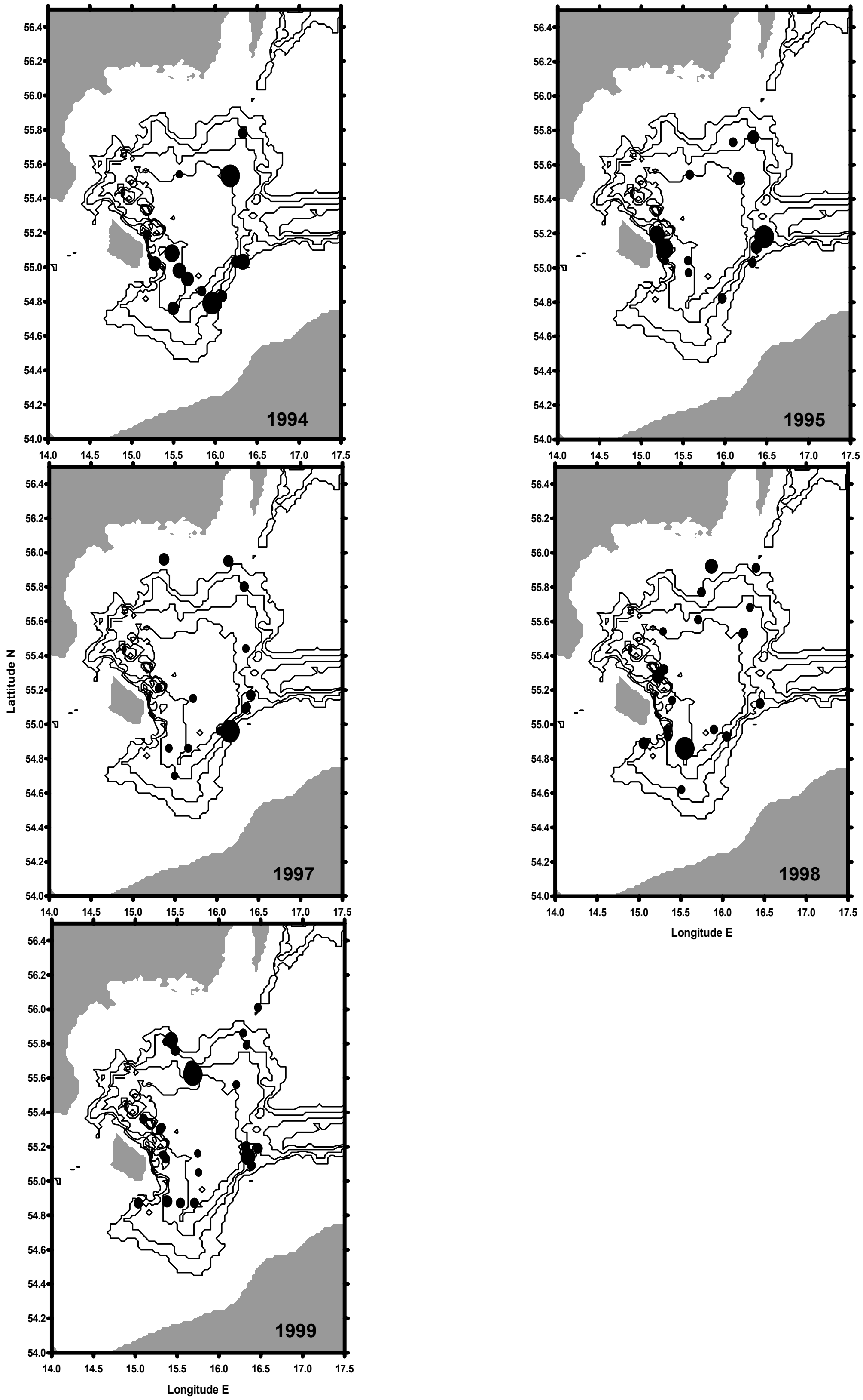


Fig. 1.1.30. Cod CPUE in the Bornholm Basin during the study period. The CPUE has been scaled, for each year the smallest dot symbolizes the lowest CPUE and the largest doth the highest CPUE, respectively. Hence, trends in absolute density are not shown on this graph. The basin's bottom topography is documented by inserting the 50m, 60m, 70m, 80m and 90 m depth contour lines (from outside towards the center of the basin).

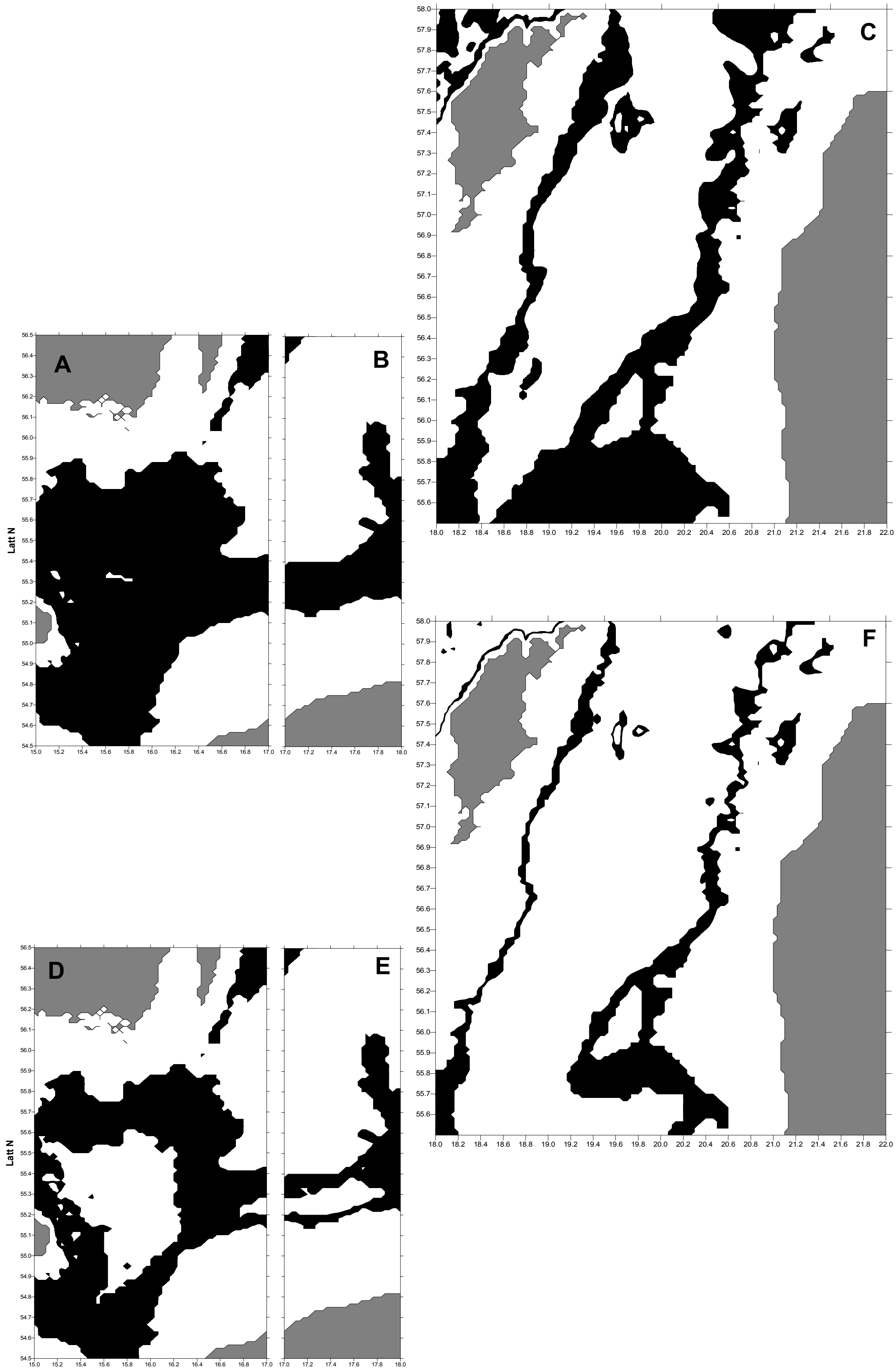


Fig. 1.1.31. Bottom area in the three different areas covered by water with suitable oxygen saturation and salinity for cod in 1994 (A to C) and 1999 (D to F). Please note the reduction in the habitat area in the center of the Bornholm Baisn, the Slupsk Furrow and the south-eastern part of the Gotland Basin.

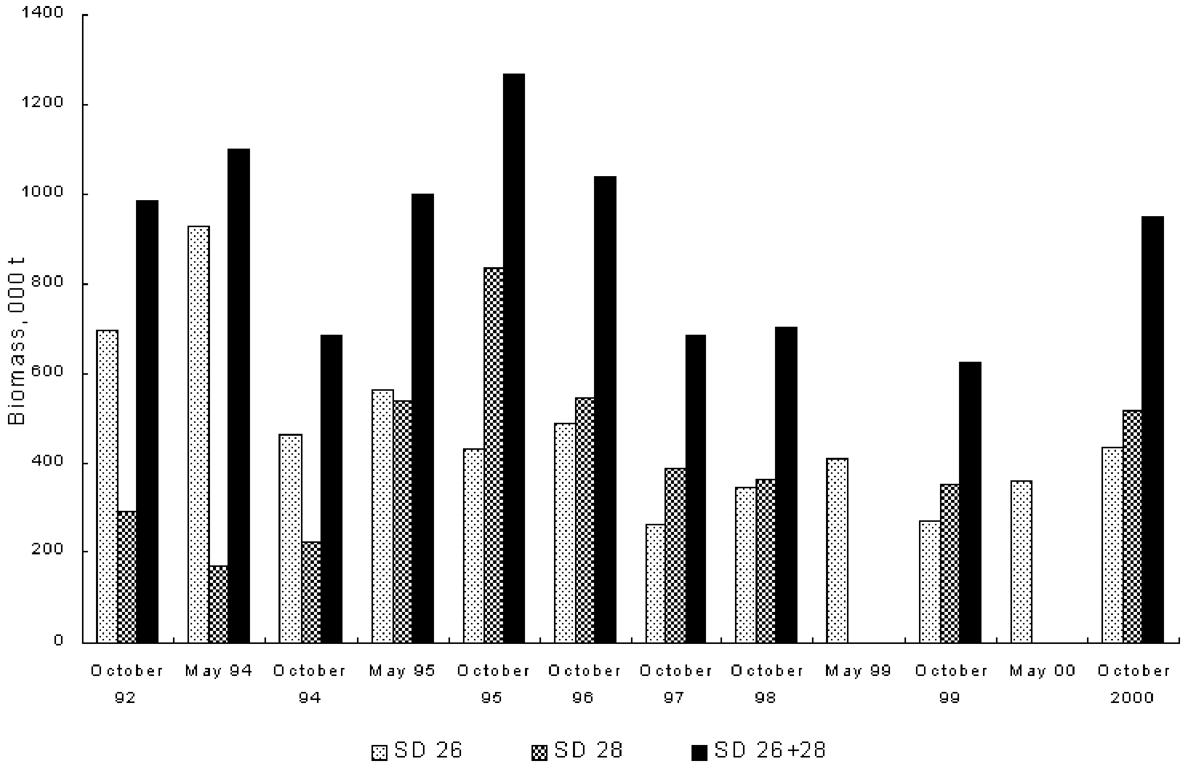
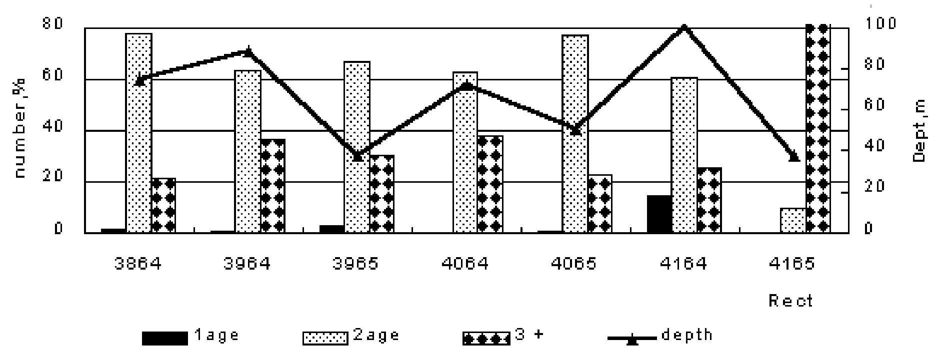
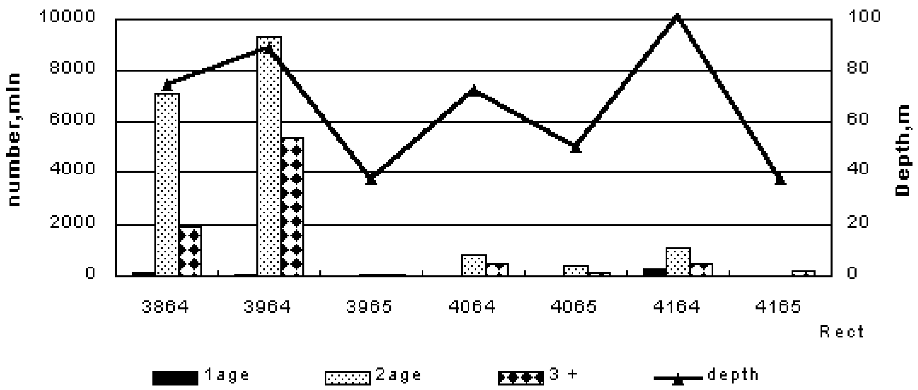


Fig. 1.1.32. Sprat biomass re-distribution between SD 26 and 28 in 1992 – 2000; Hydroacoustic surveys R/V Monocrystall, Atlantniro.

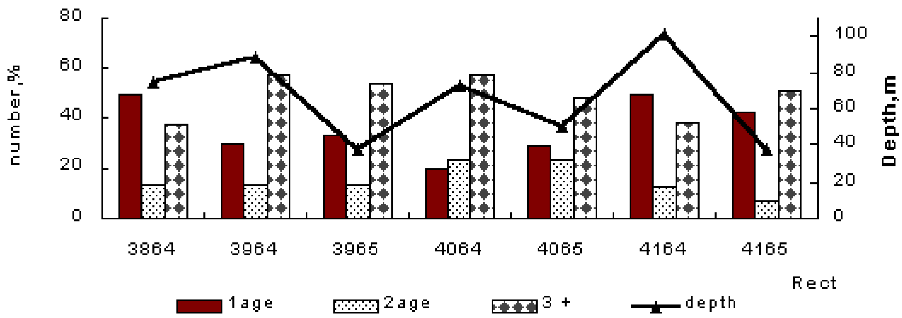
Estimated number (%) of sprat in SD 26 (R / V "Monokristall ",May 1994)



Estimated number (millions) of sprat in SD 26 (R / V "Monokristall ",May 1994)



Estimated number (millions,%) of Sprat R/V " Monokistall ", May 1995.



Estimated number (millions) of Sprat R/V " Monokistall ", May 1995.

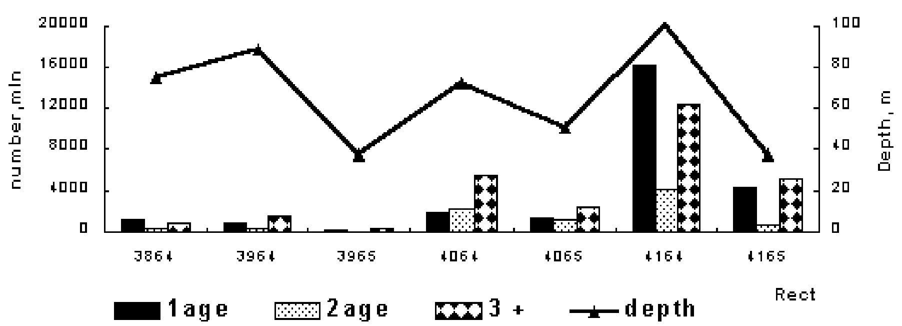
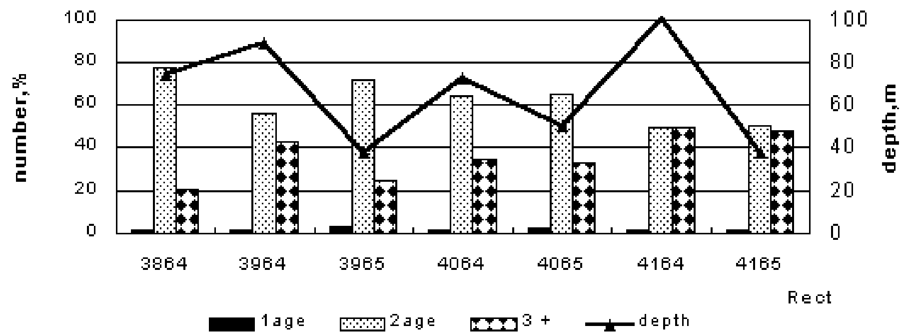


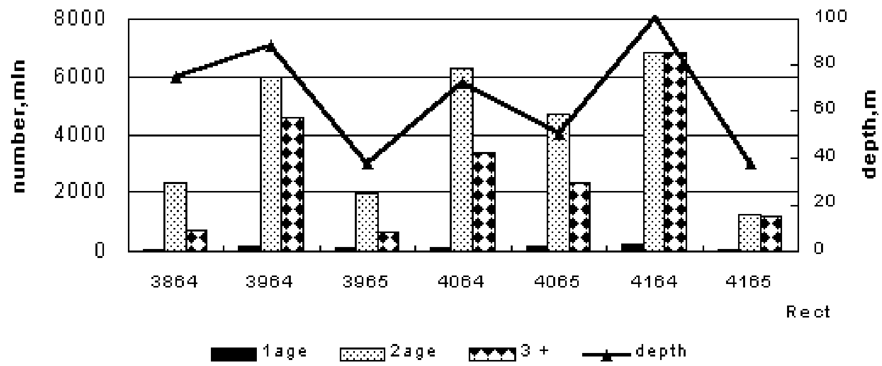
Fig. 2

Fig. 1.1.33. Estimated relative proportion and absolute numbers of sprat in Sub-division 26 at peak spawning times in 1994, 1995, 1999 and 2000.

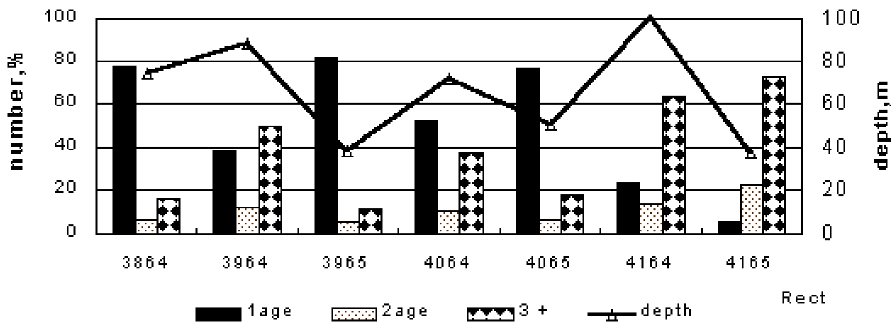
Estimated number (%) of sprat in SD 26 (R / V "AtlantNIRO ",May 1999)



Estimated number (millions) of Sprat R/V " AtlantNIRO ", May 1999.



Estimated number (millions,%) of sprat in SD 26 (R / V "Atlantida ", May, June 2000)



Estimated number (millions) of sprat in SD 26 (R / V "Atlantida ", May, June 2000)

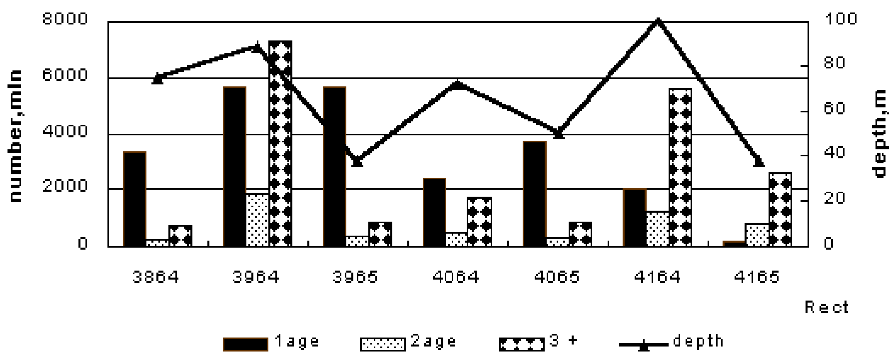


Fig.3

Fig. 1.1.33 (continued). Estimated relative proportion and absolute numbers of sprat in Sub-division 26 at peak spawning times in 1994, 1995, 1999 and 2000.

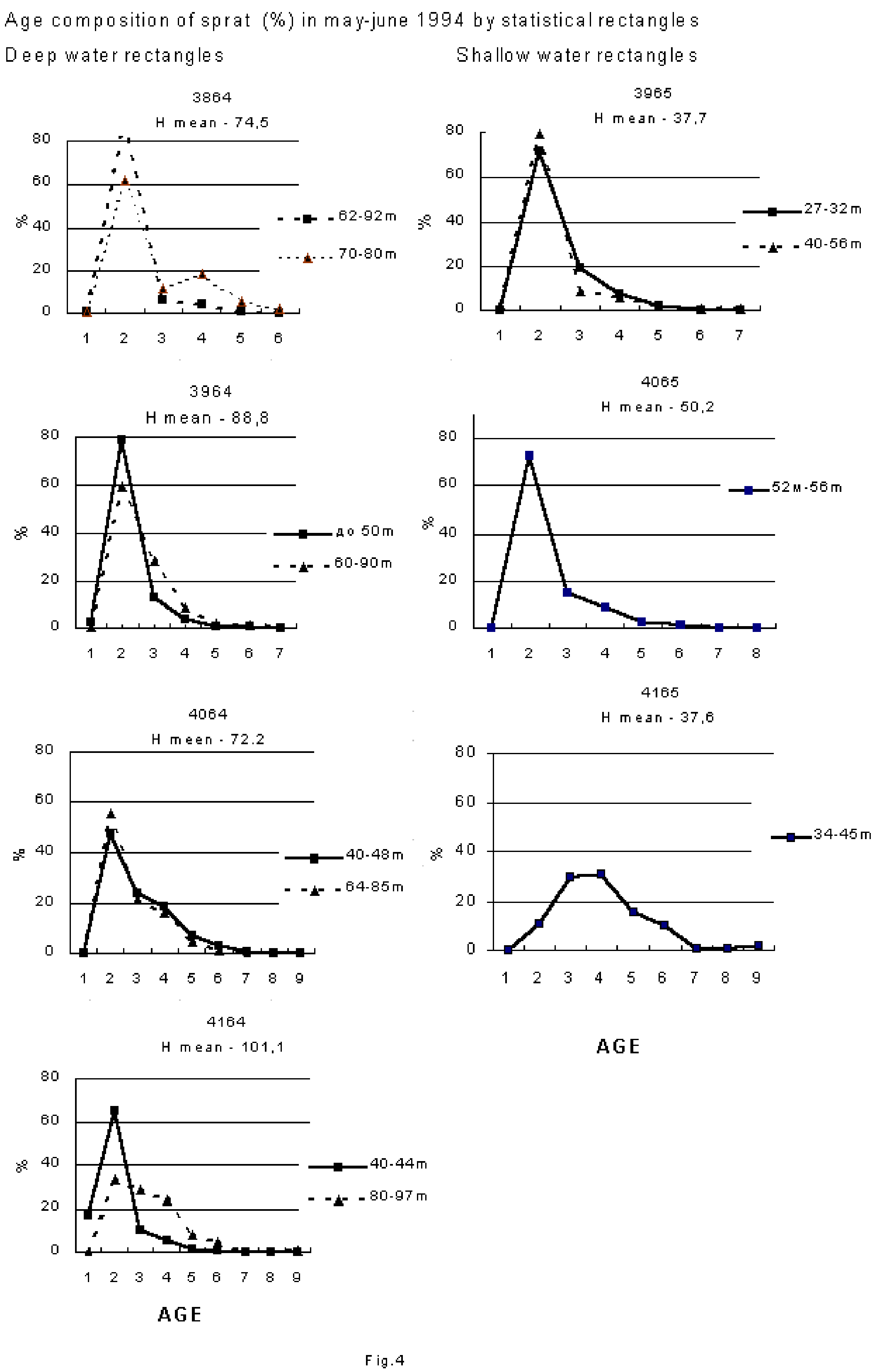


Fig. 1.1.34. Age composition of sprat (%) at peak spawning time in 1994 by statistical rectangle according to deep water and shallow water rectangles.

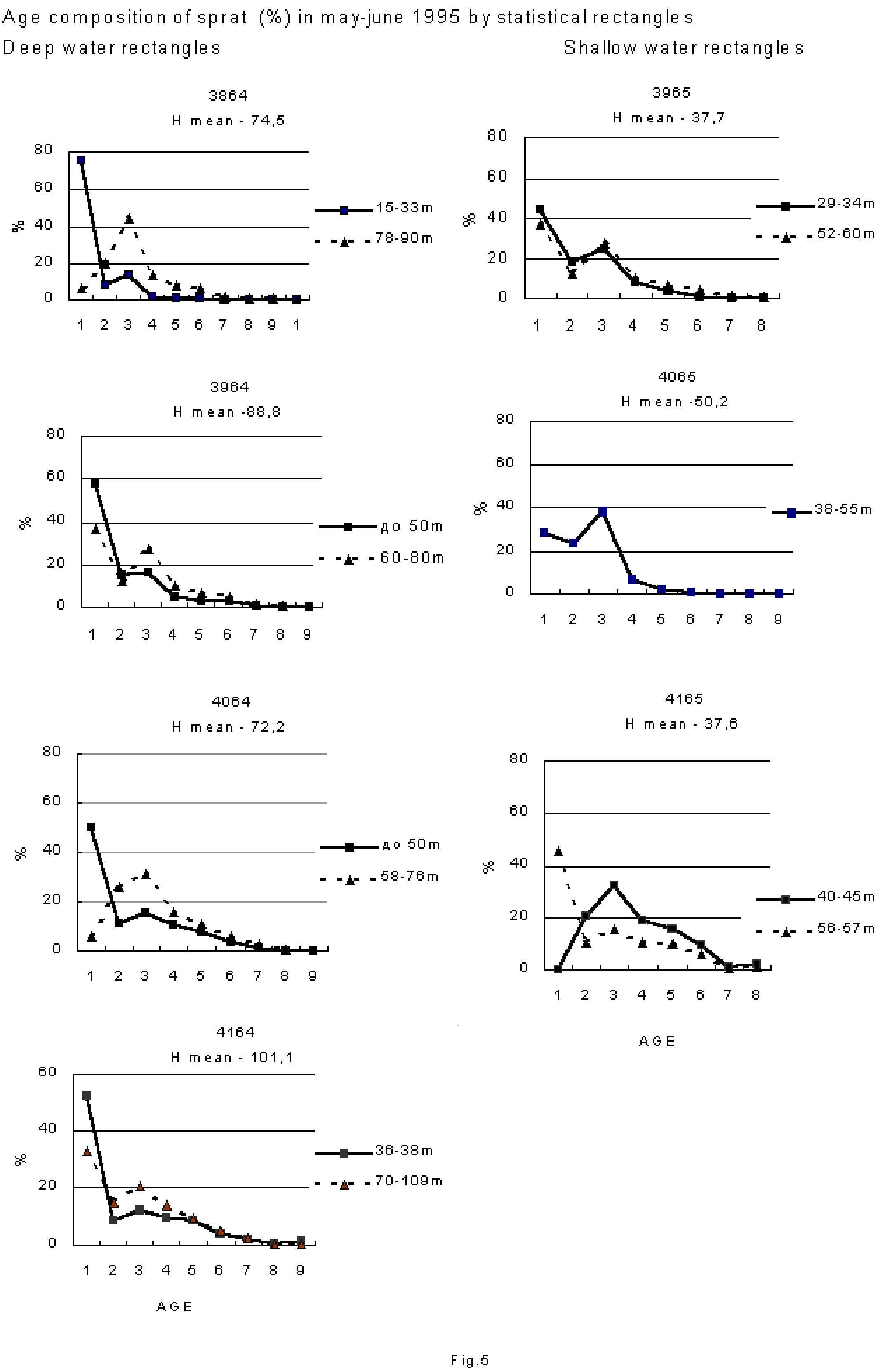


Fig. 1.1.35. Age composition of sprat (%) at peak spawning time in 1995 by statistical rectangle according to deep water and shallow water rectangles.

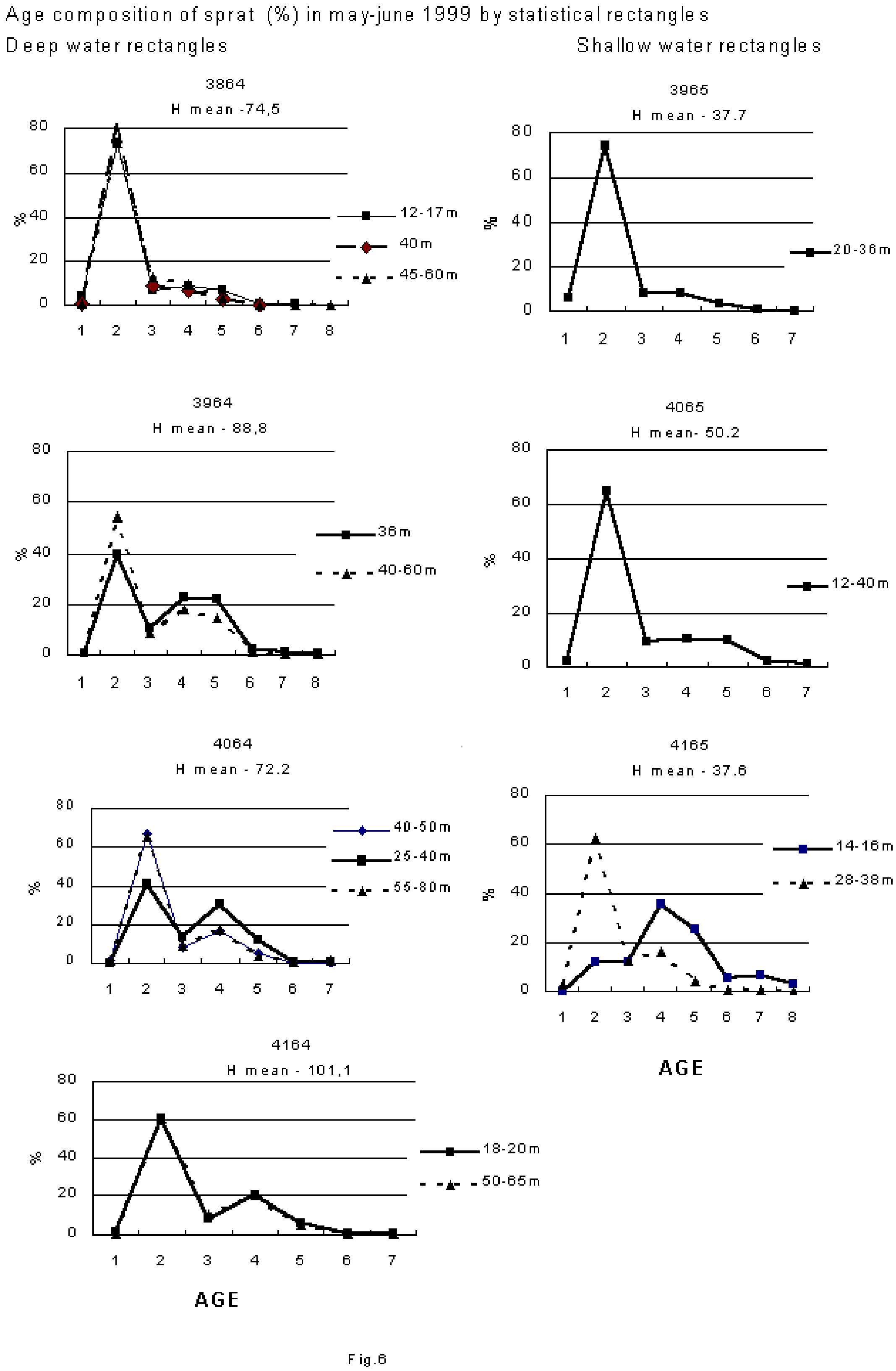


Fig. 1.1.36. Age composition of sprat (%) at peak spawning time in 1999 by statistical rectangle according to deep water and shallow water rectangles.

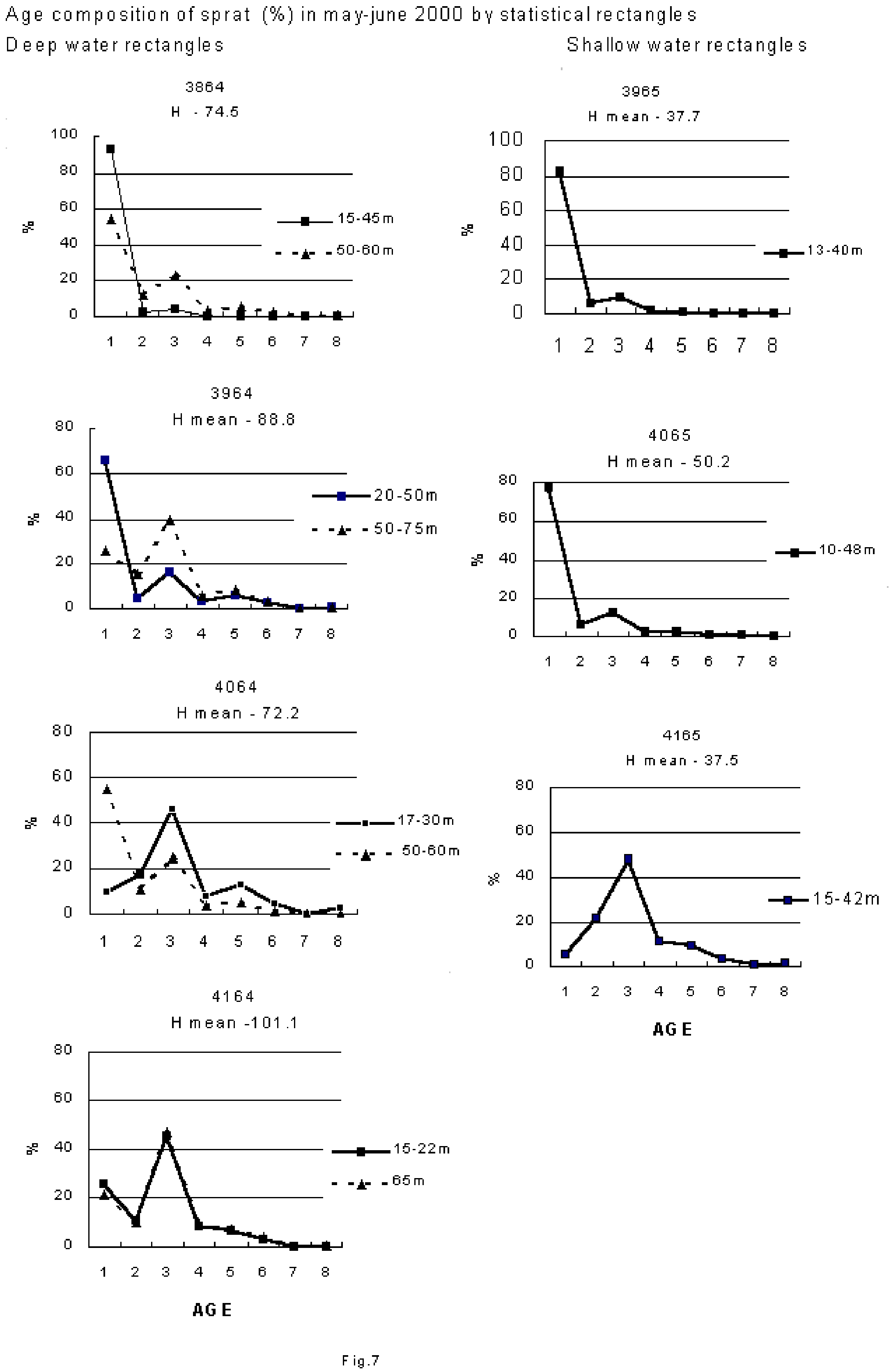


Fig. 1.1.37. Age composition of sprat (%) at peak spawning time in 2000 by statistical rectangle according to deep water and shallow water rectangles.

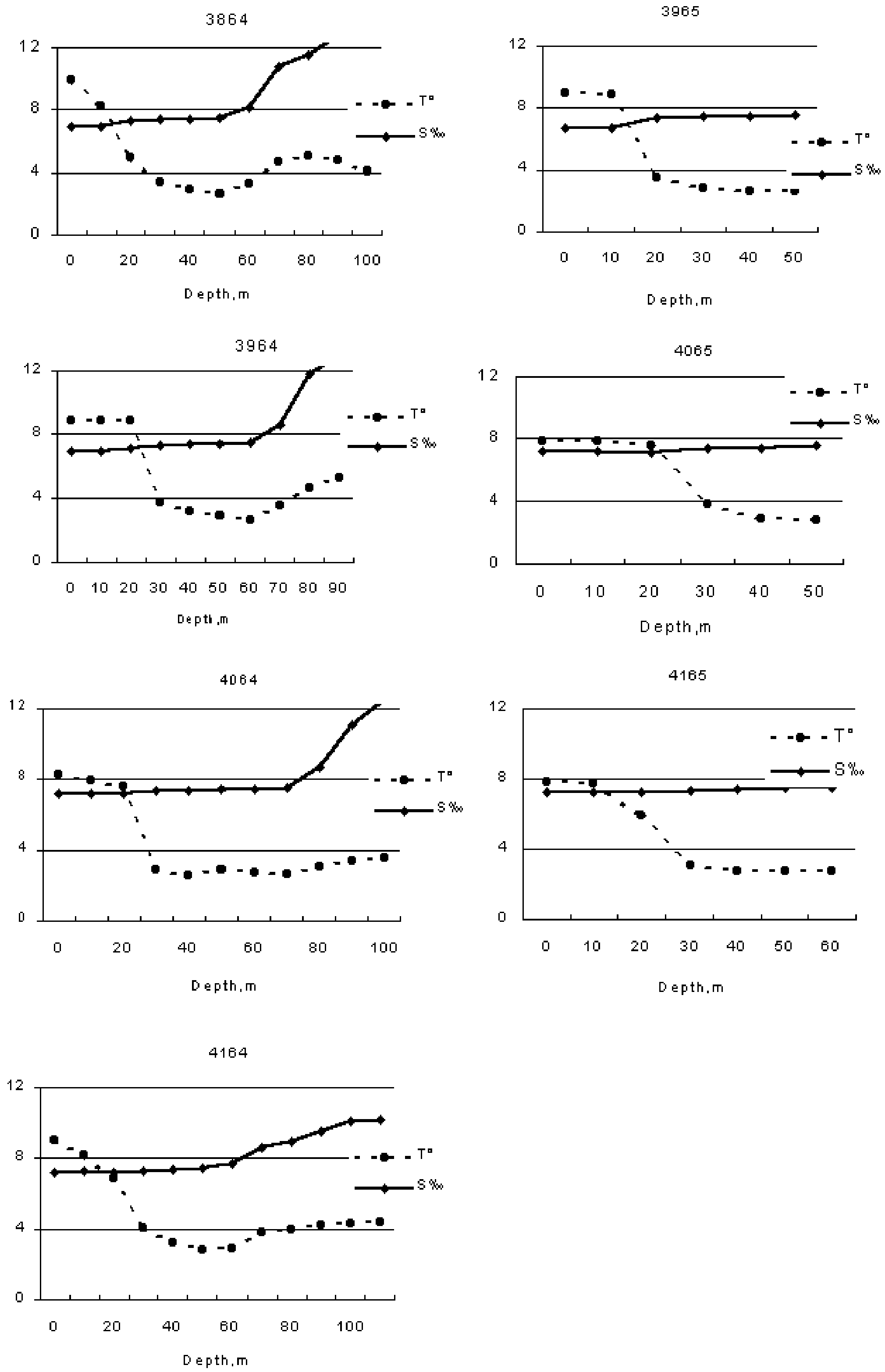


Fig. 1.1.38. Water temperature (°C) and salinity (PSU) by depth strata and statistical rectangle during peak spawning time in 1994.

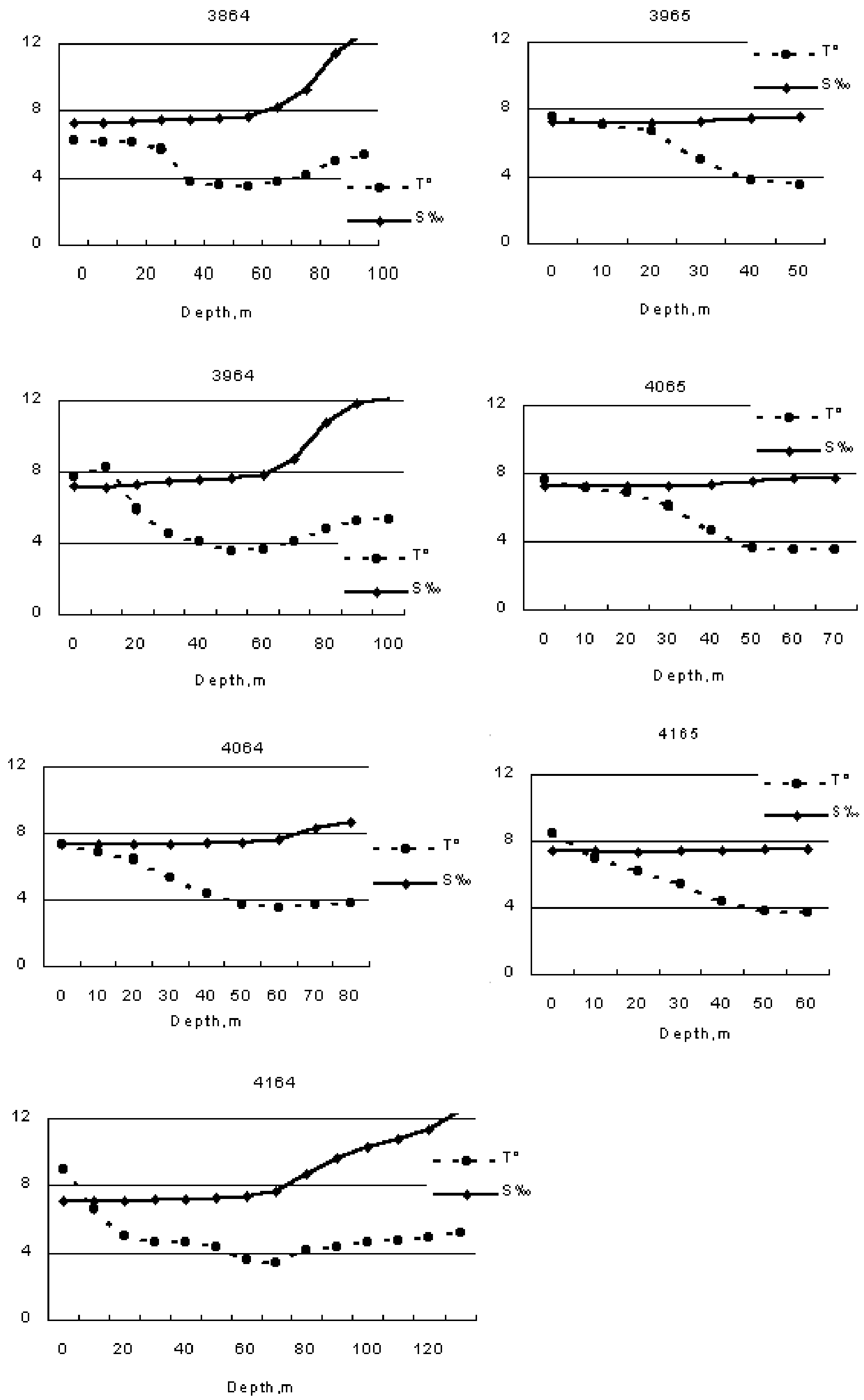


Fig. 1.1.39. Water temperature (°C) and salinity (PSU) by depth strata and statistical rectangle during peak spawning time in 1995.

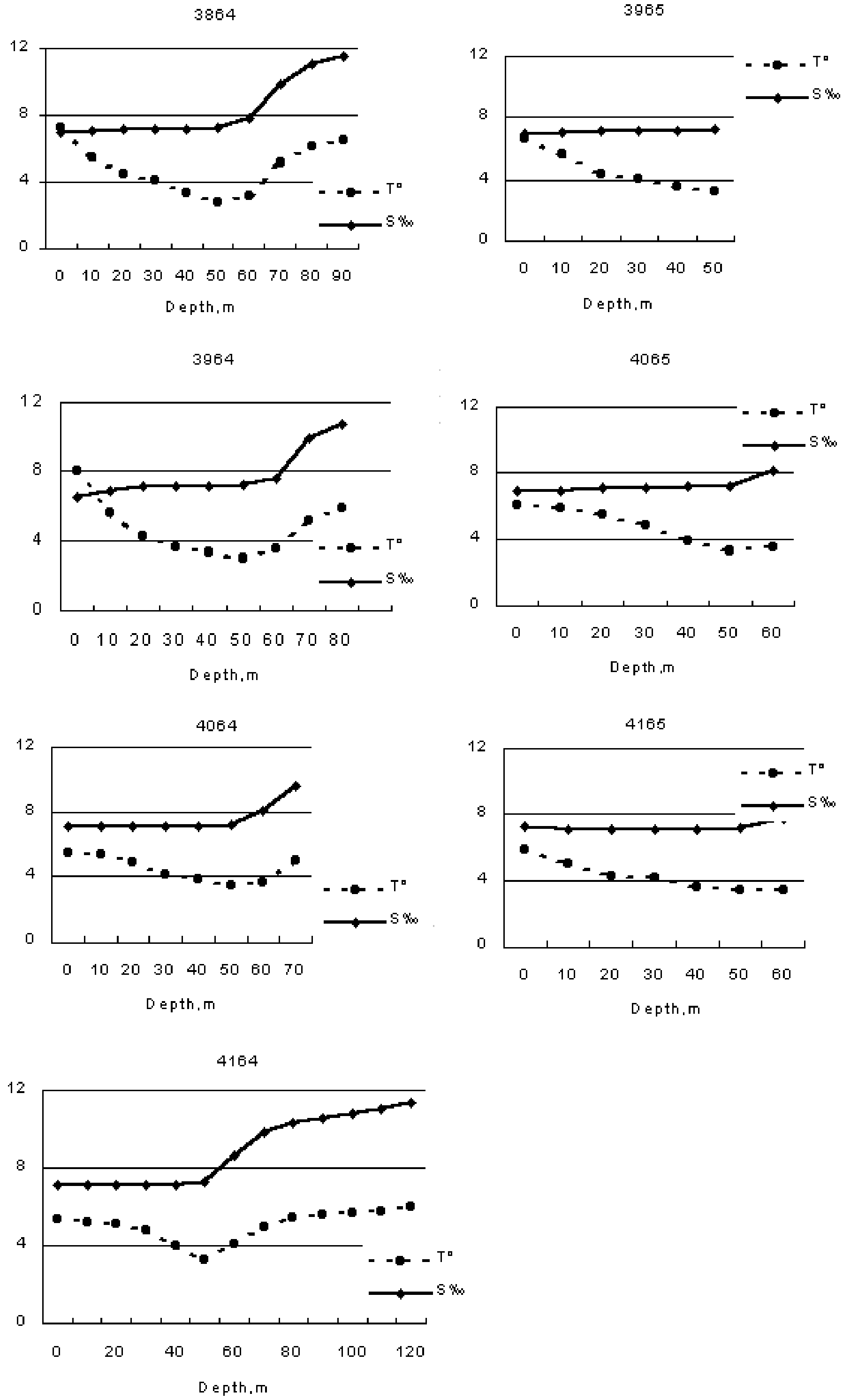


Fig. 1.1.40. Water temperature (°C) and salinity (PSU) by depth strata and statistical rectangle during peak spawning time in 1999.

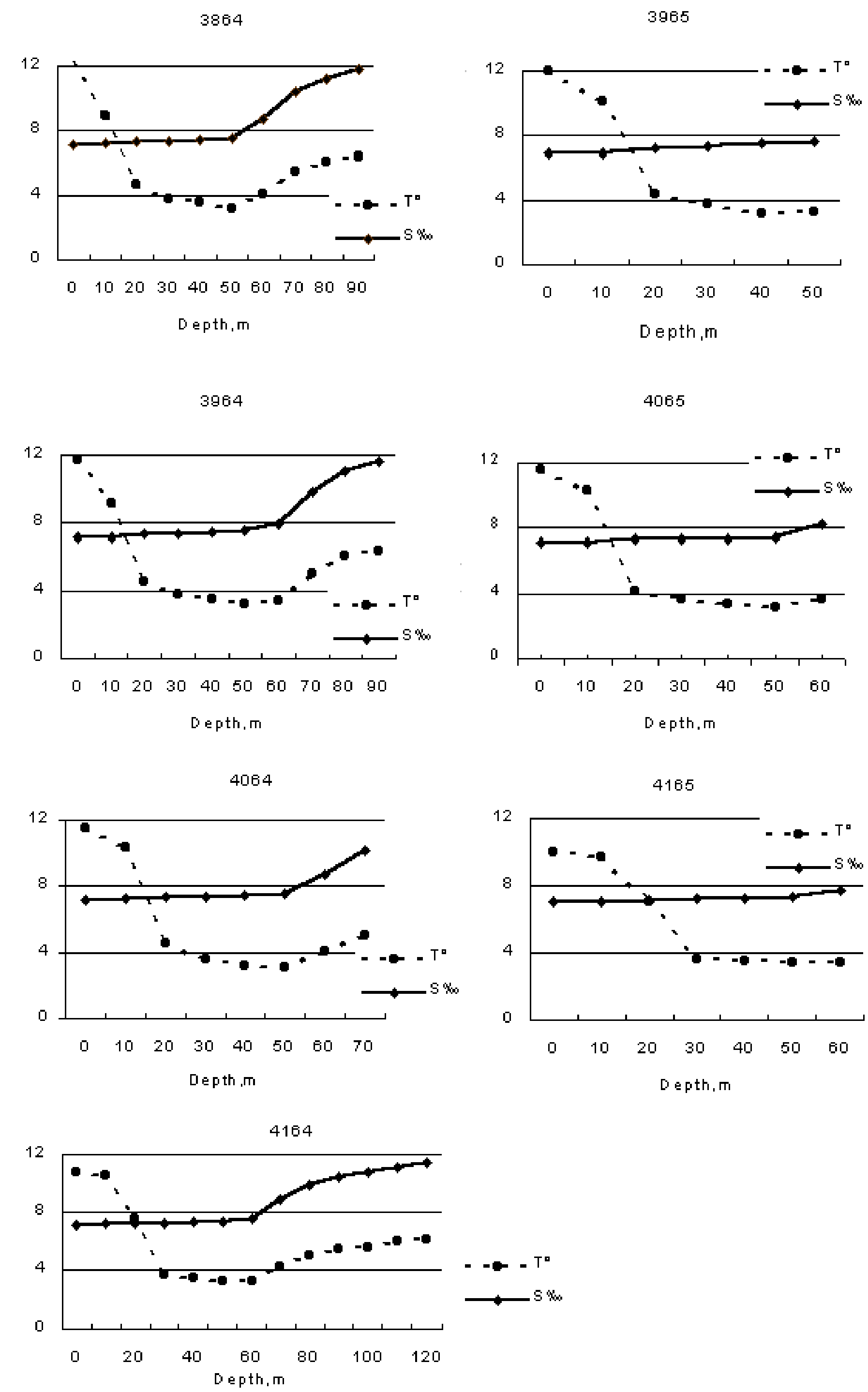


Fig. 1.1.41. Water temperature (°C) and salinity (PSU) by depth strata and statistical rectangle during peak spawning time in 2000.

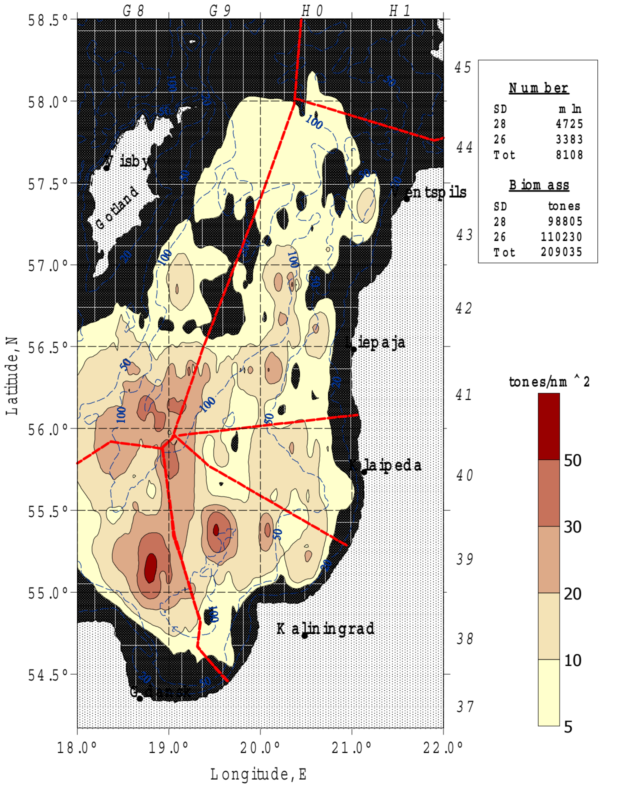


Fig.1.1.42. Distribution of sprat density in the Baltic Sea, May 1987.

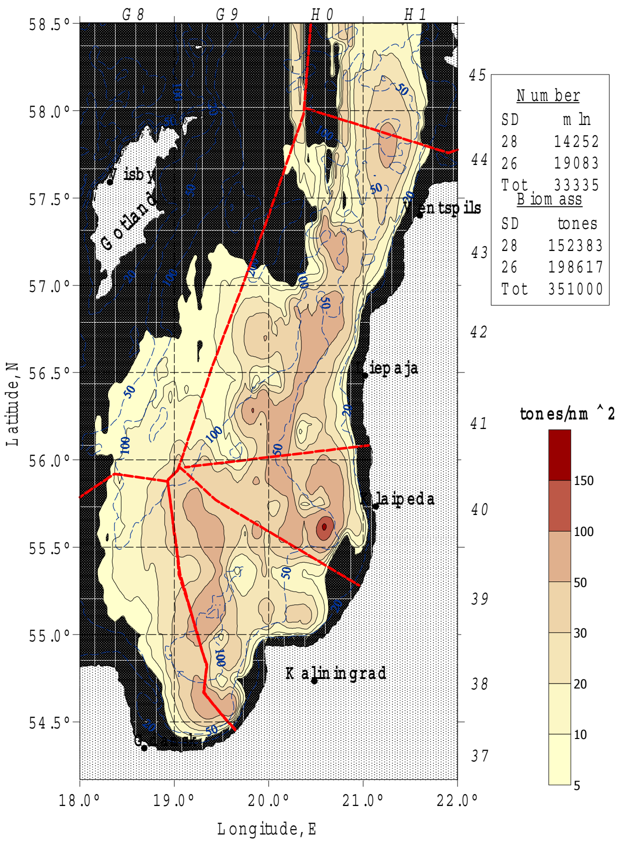


Figure 1.1.43. Distribution of sprat density in the Baltic Sea, October 1987.

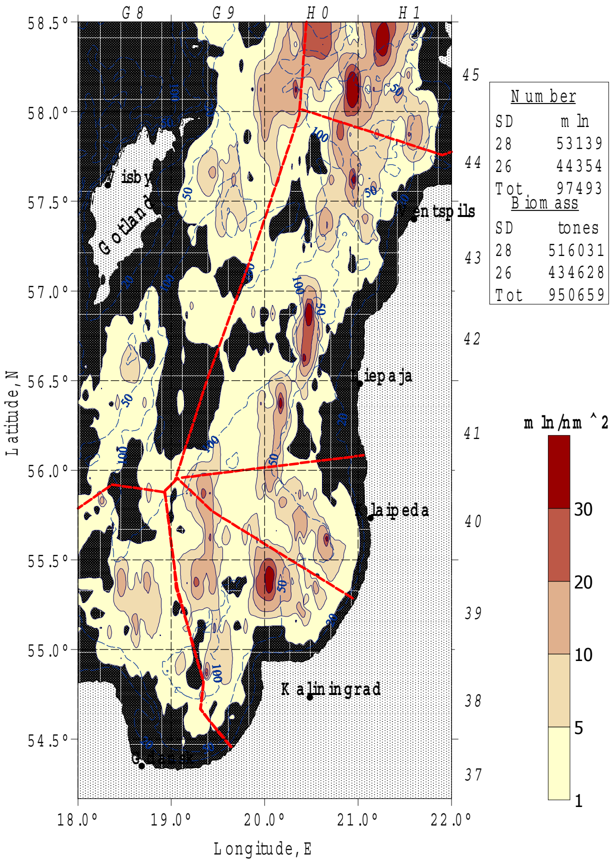


Figure 1.1.44. Distribution of sprat density in the Baltic Sea, October 2000

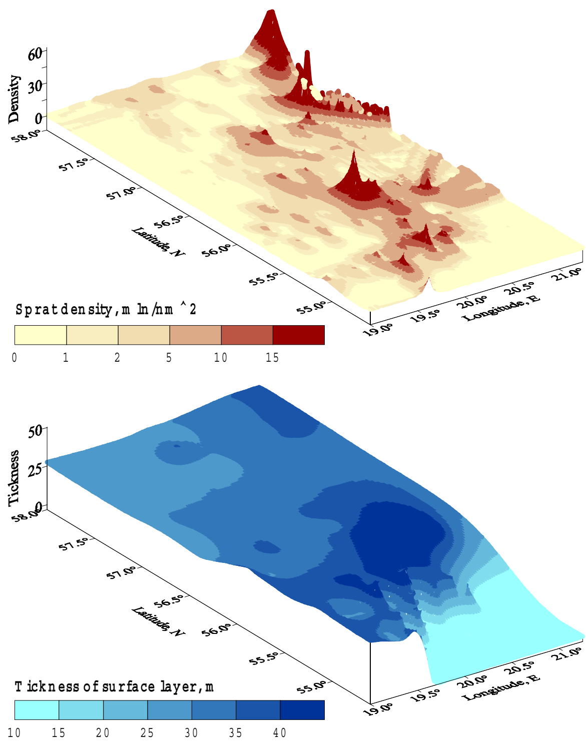


Figure 1.1.45. Distribution of sprat density in surface layer in the Baltic Sea, October 1998

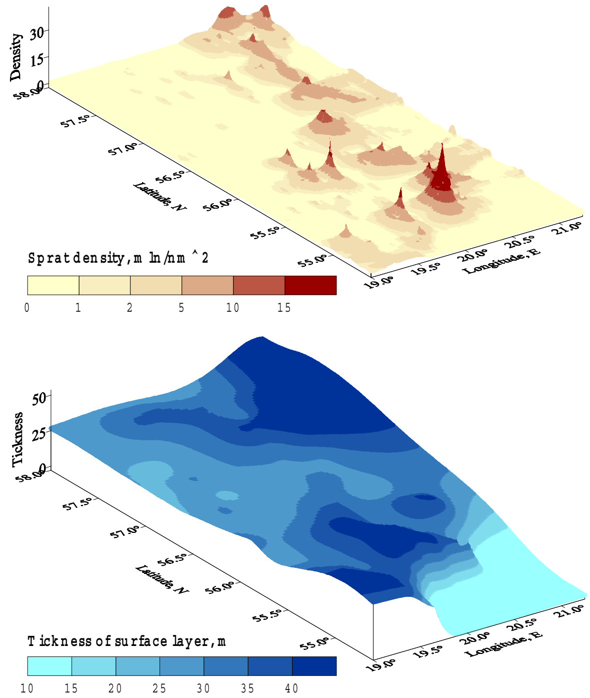


Figure 1.1.46. Distribution of sprat density in surface layer in the Baltic Sea, October 2001

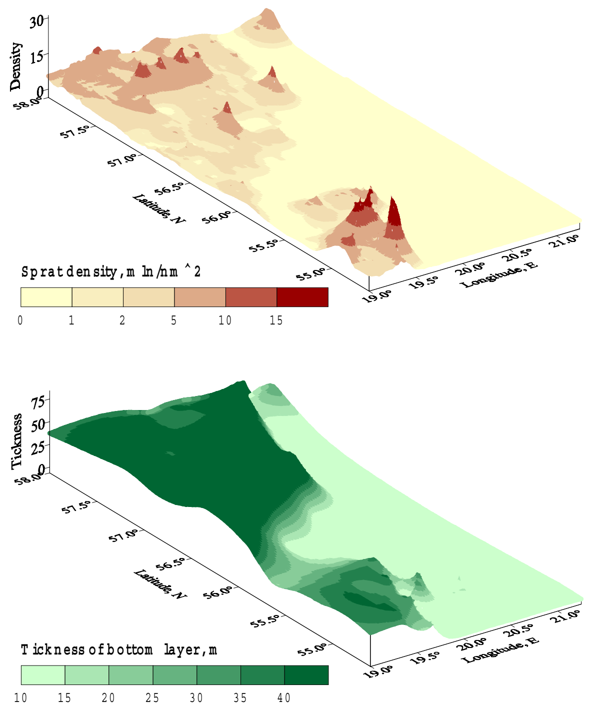


Figure 1.1.47. Distribution of sprat density in bottom layer in the Baltic Sea, October 1998

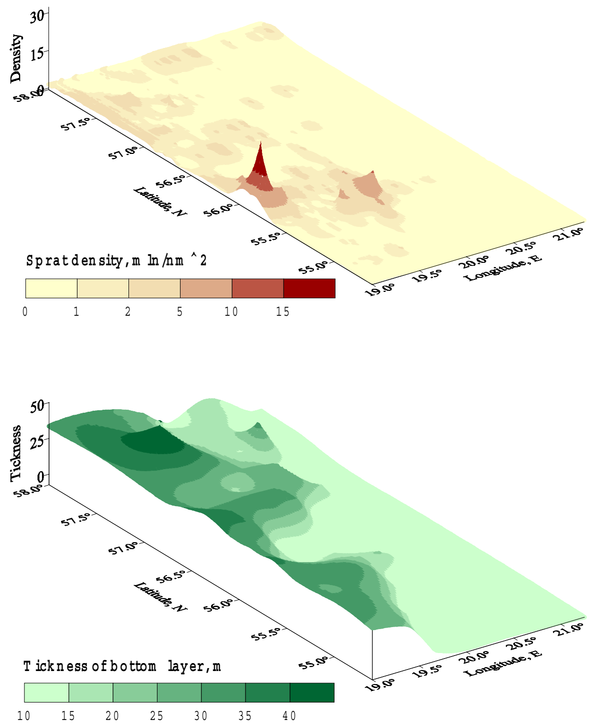


Figure 1.1.48. Distribution of sprat density in bottom layer in the Baltic Sea, October 2001.

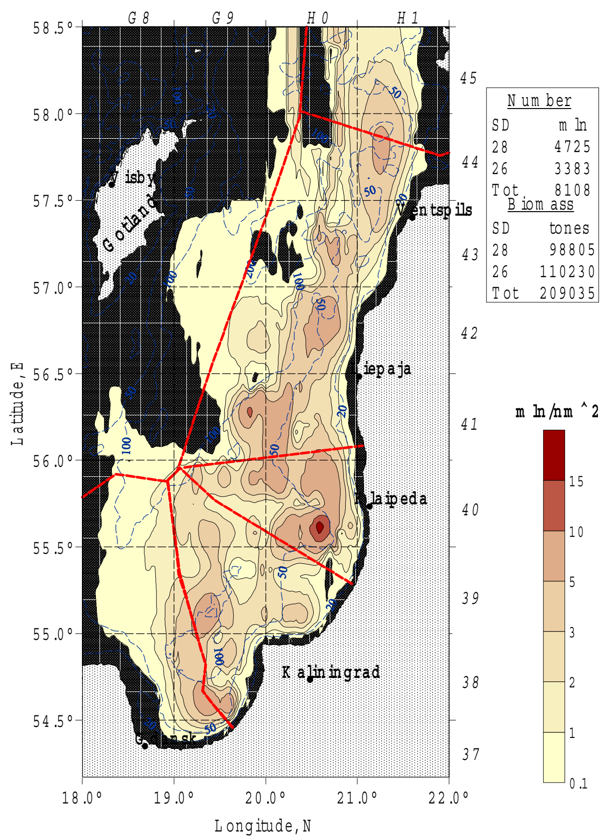


Figure 1.1.49. (a) Distribution of sprat density at age 1 in the Baltic Sea, October 1987.

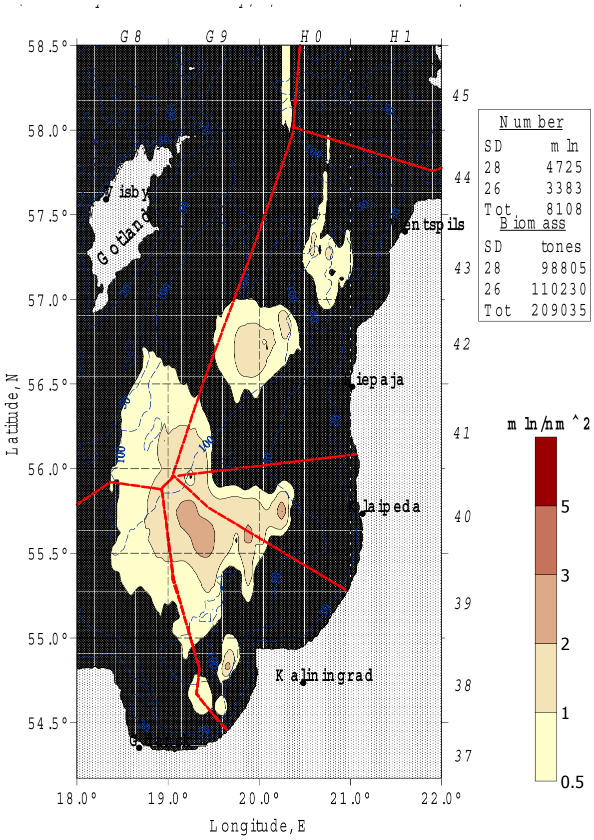


Figure 1.1.49. (b) Distribution of sprat density at age 2 and older in the Baltic Sea, October 1987.

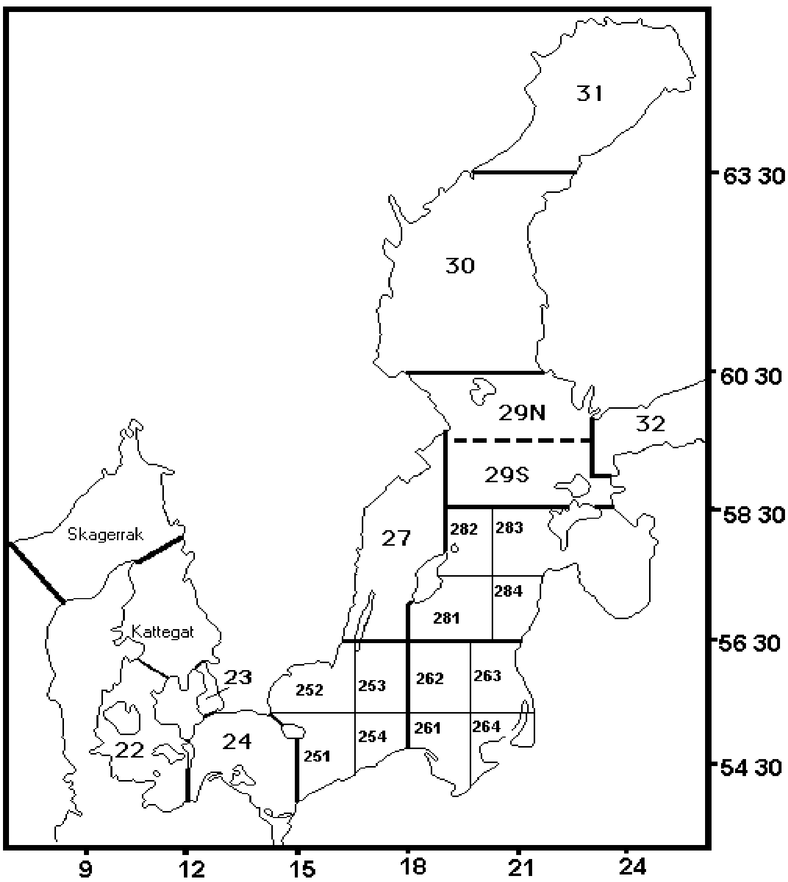


Fig. 1.1.50. Sub-areas of the Central Baltic Sea used in the analysis of the spatial distribution of cod.

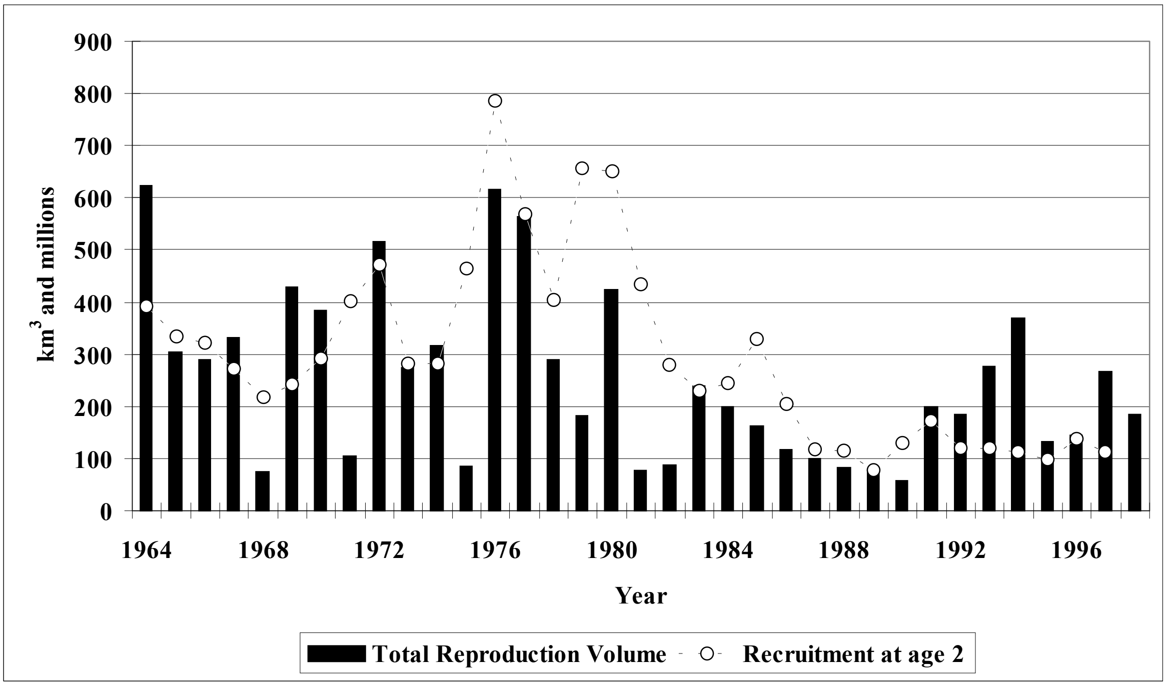


Fig. 1.1.51a.Total reproduction volume and corresponding recruitment at age 2 in the eastern Baltic cod stock in 1964-1998 (recruitment at age 2 shifted two years back to correspond year of birth (ICES 1999a). (RVs courtesy of M. Plikshs, March 2000, R from ICES 1999a).

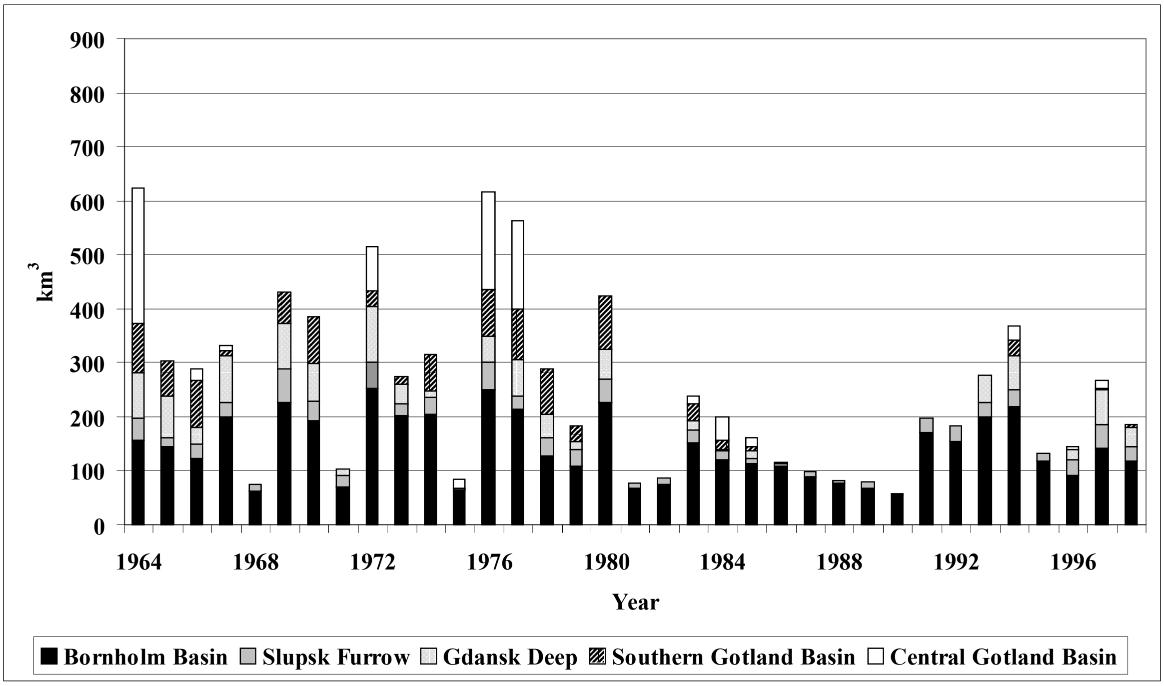


Fig.1.1.51b. Total reproduction volume and contribution of various spawning grounds to total reproduction volume in 1964-1998.

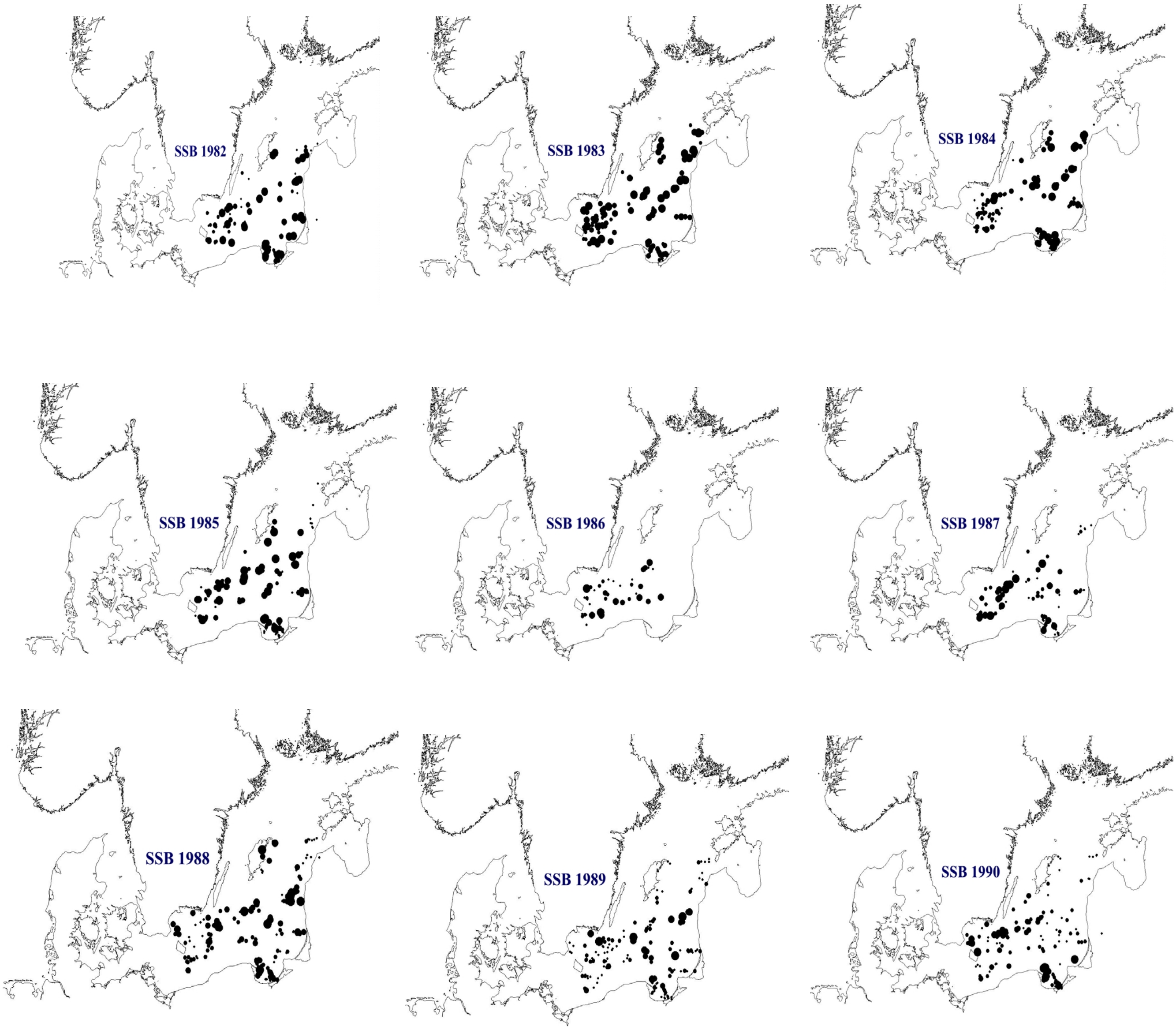


Fig. 3.1.52a. Distribution of SSB of Baltic cod in February-March in 1982-1990.

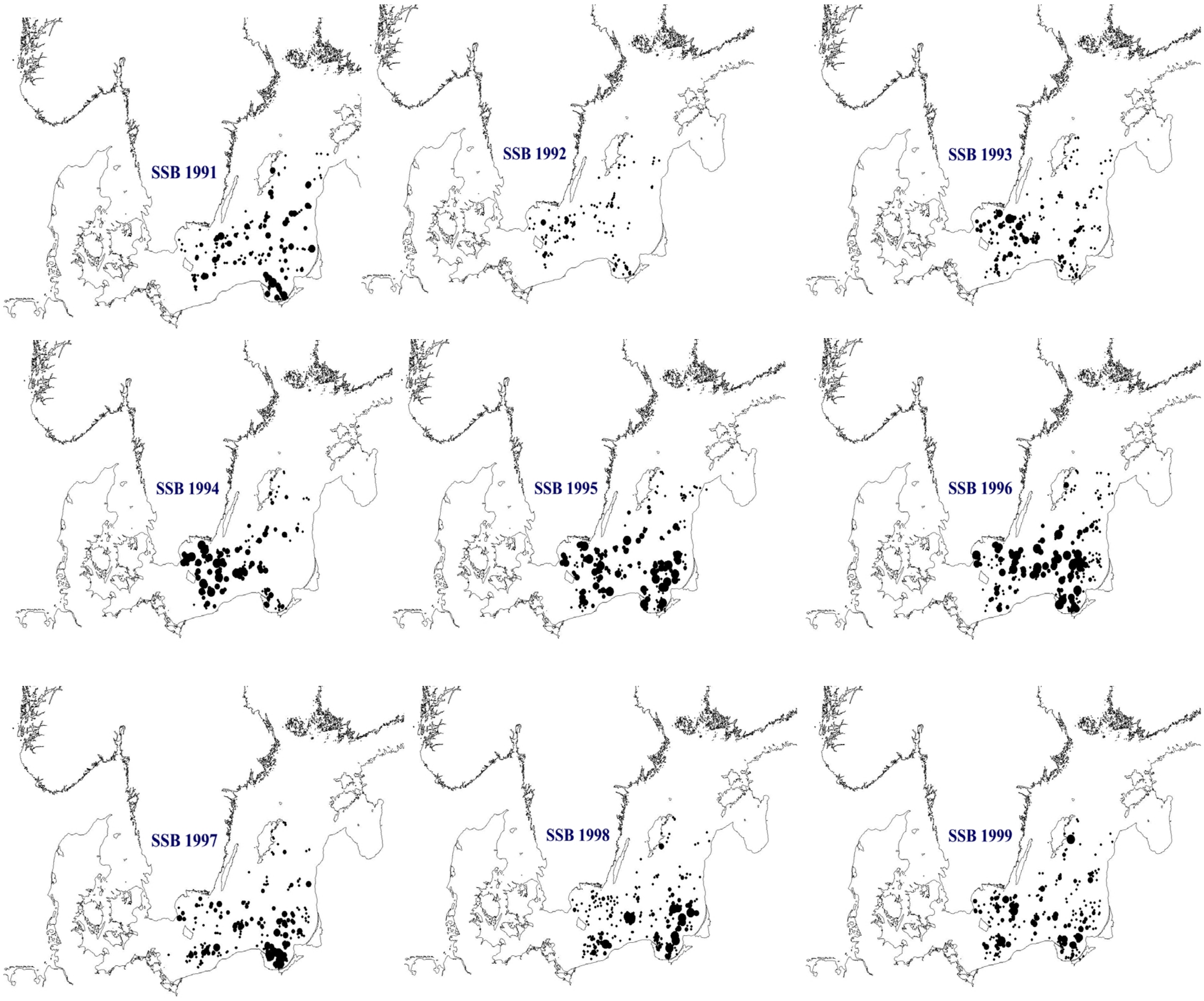


Fig. 3.1.52b. Distribution of SSB of Baltic cod in February-March in 1991-1999.

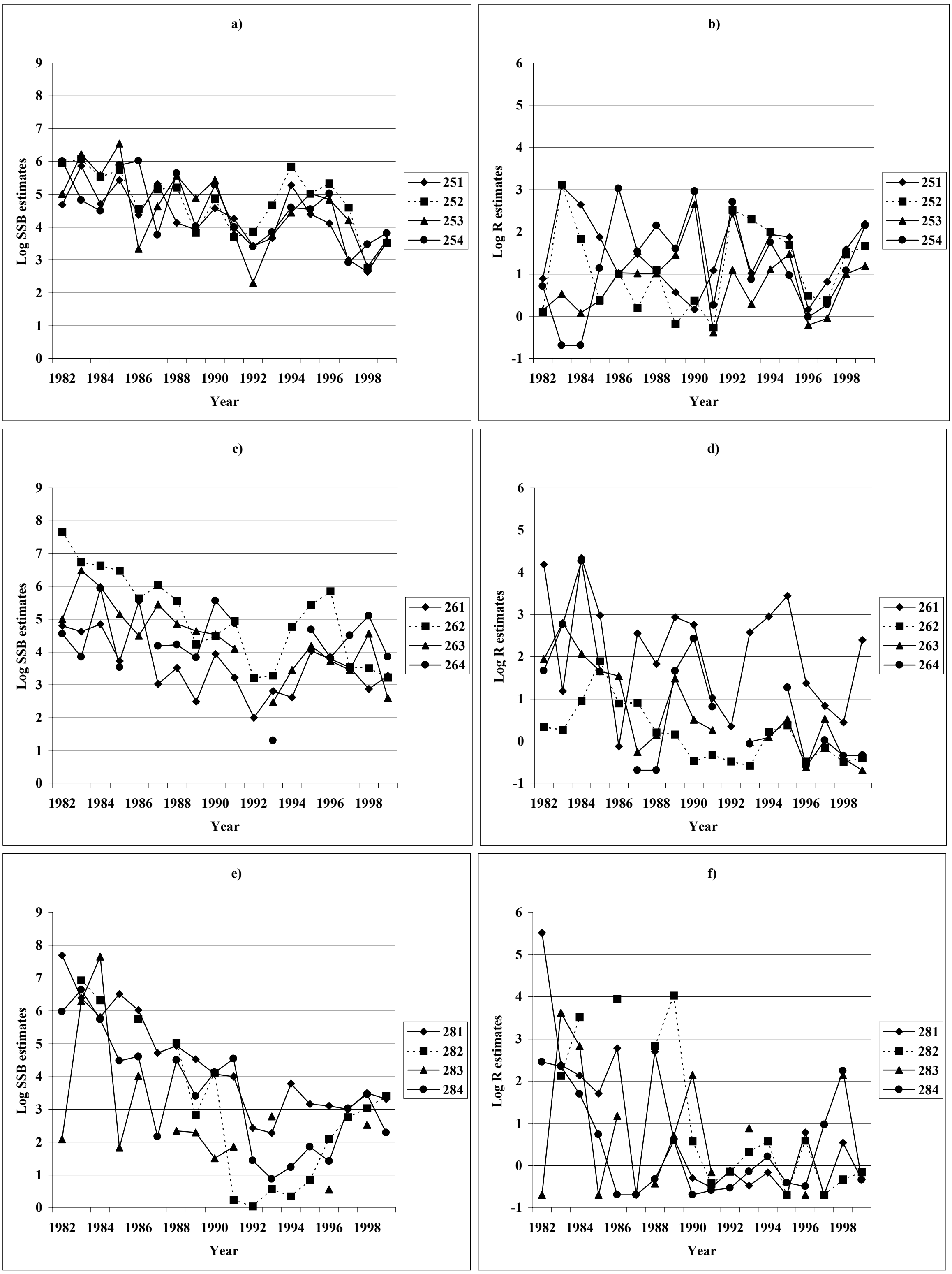


Fig. 1.1.53a-f. Least squares/h of SSB and recruitment at age 1 [R] of cod in different areas of the Central Baltic for the time period 1982-1999.

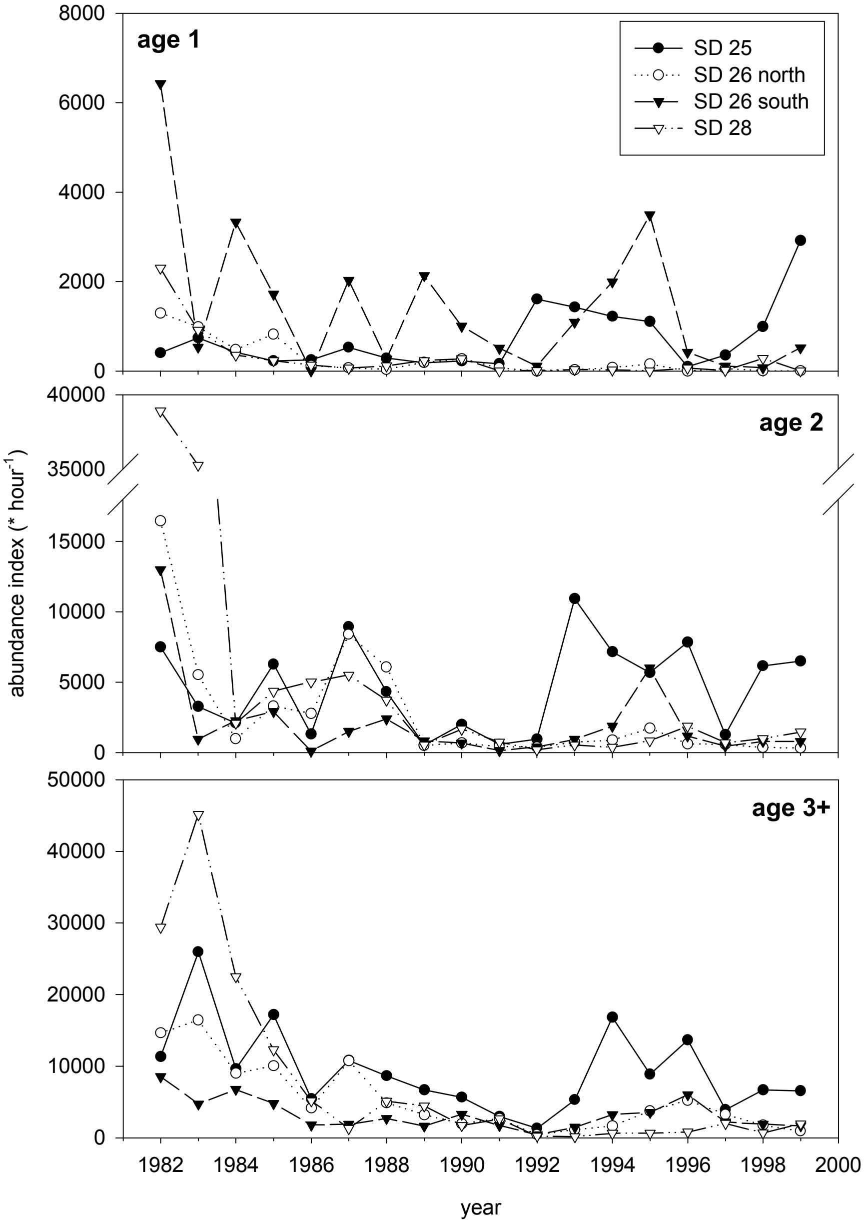


Fig. 1.1.54. Abundance indices for cod age 1, 2 and 3+ in the Central Baltic per Sub-division (SD).

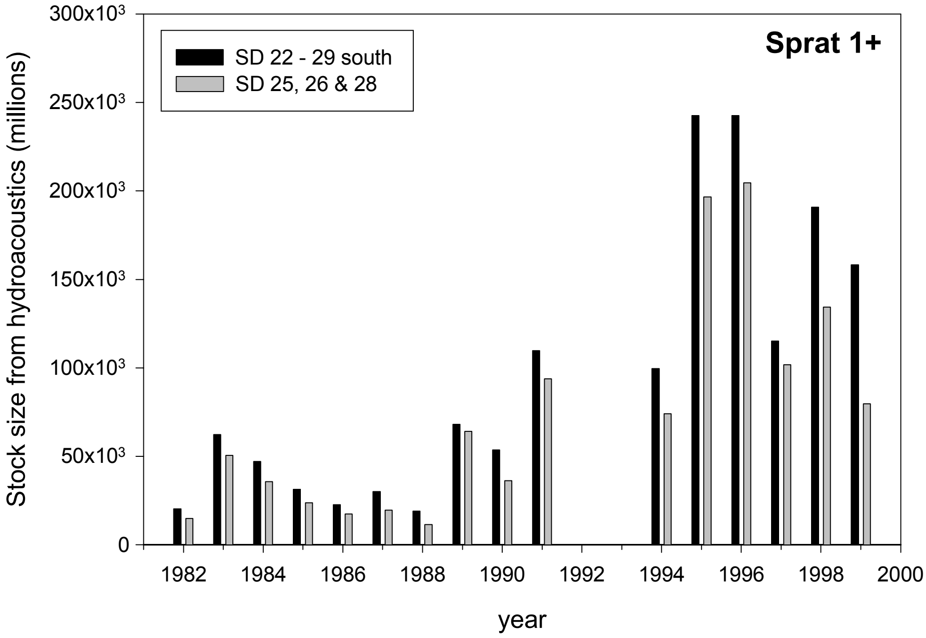


Fig. 1.1.55. Stock size of sprat age 1+ derived from autumn hydroacoustic survey:Sub-divisions (SD) 22-29 south compared to combined SD 25, 26 ad 28.

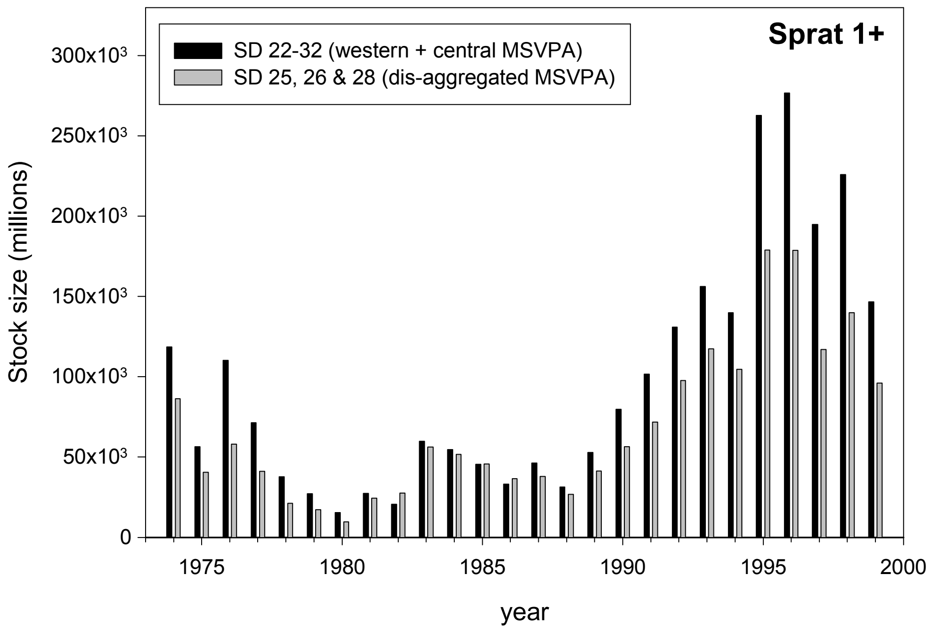


Fig. 1.1.56. Stock size of sprat age 1+ :Sub-divisions (SD) 22-32 derived from combined western & central MSVPA compared to combined SD 25, 26 ad 28 from area dis-aggregated MSVPA.

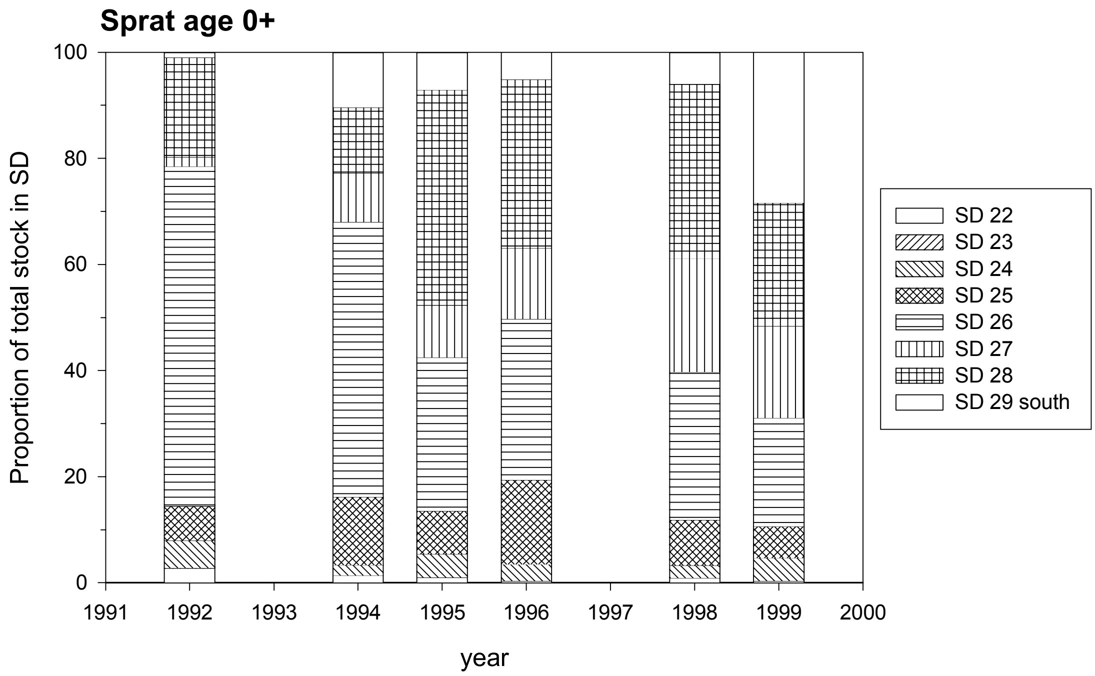


Fig. 1.1.57. Relative spatial distribution of sprat stock sizes (age 0+) from hydroacoustic surveys in September/October in the Baltic Sea.

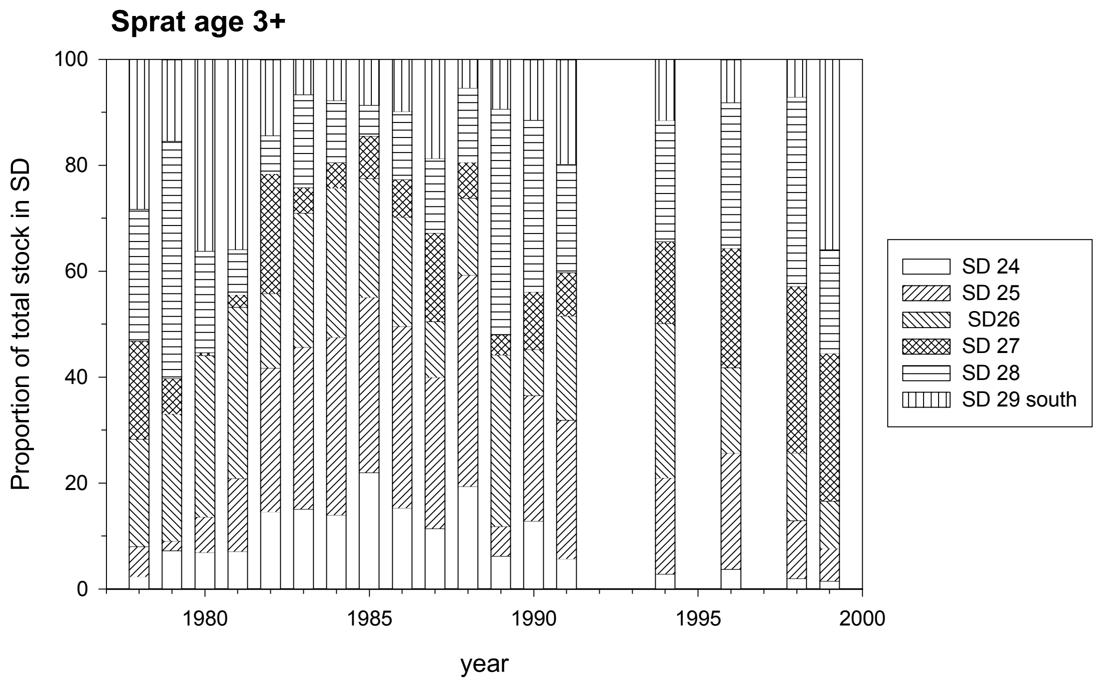


Fig. 1.1.58. Relative spatial distribution of sprat stock sizes (age 3+) from hydroacoustic surveys in September/October in the Baltic Sea.

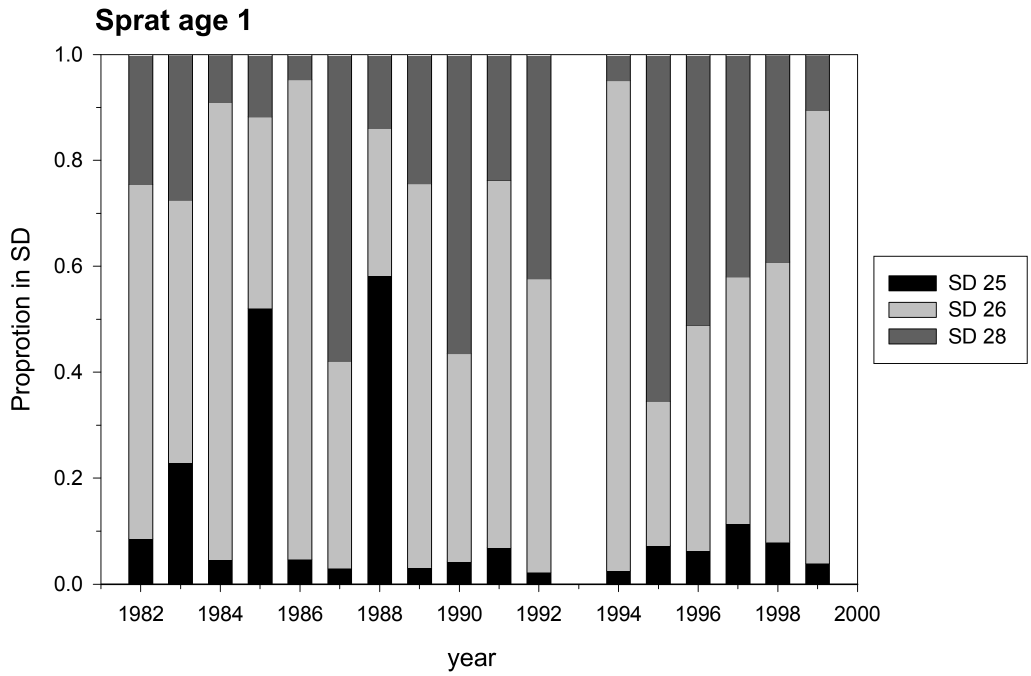


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Fig. 1.1.59. Relative spatial distribution of sprat stock sizes (age 1) from hydroacoustic surveys in September/October in the Baltic Sea.

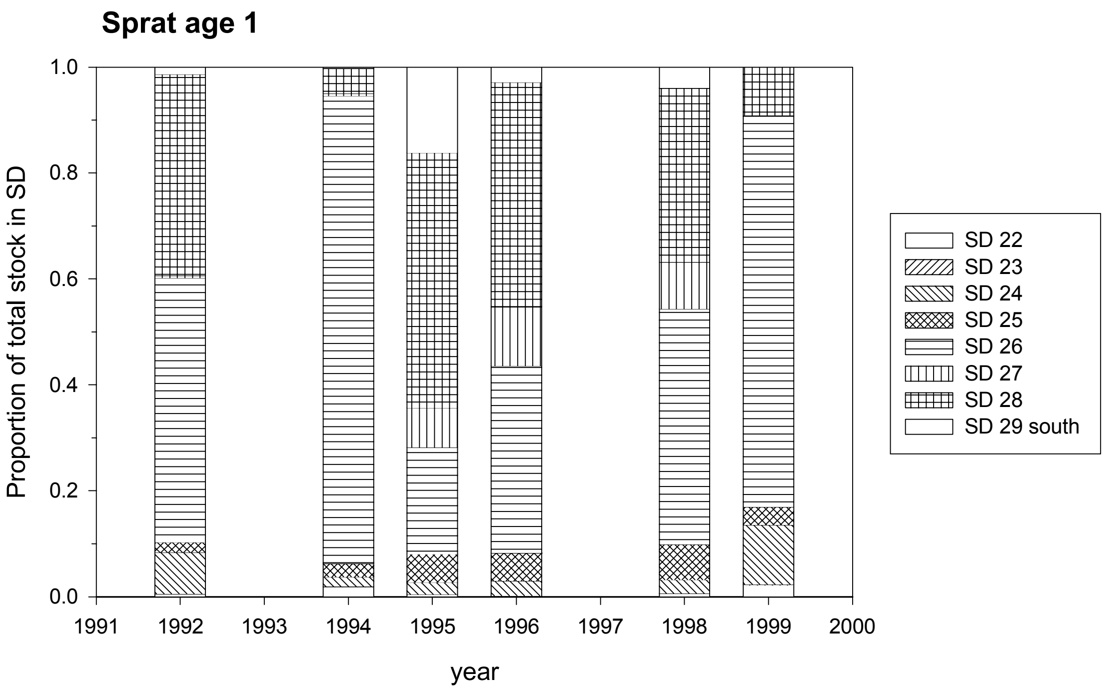


Fig. 1.1.60. Relative spatial distribution of sprat stock sizes (age 1) from hydroacoustic surveys in September/October in Sub-divisions (SD) 25, 26 and 28.

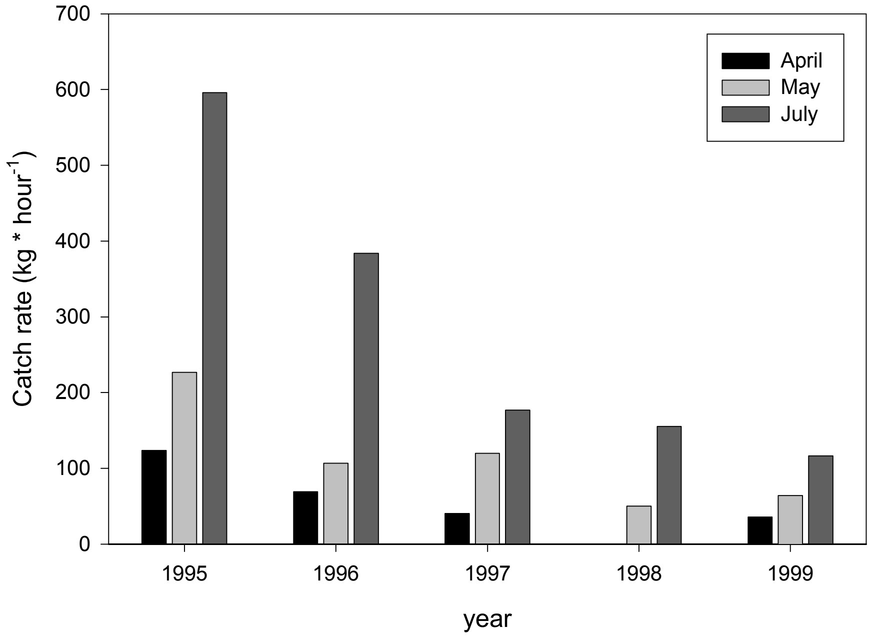


Fig. 1.1.61. Catch rates of adult cod in benthopelagic trawl surveys covering the Bornholm Basin in April, May and July 1995-1999.

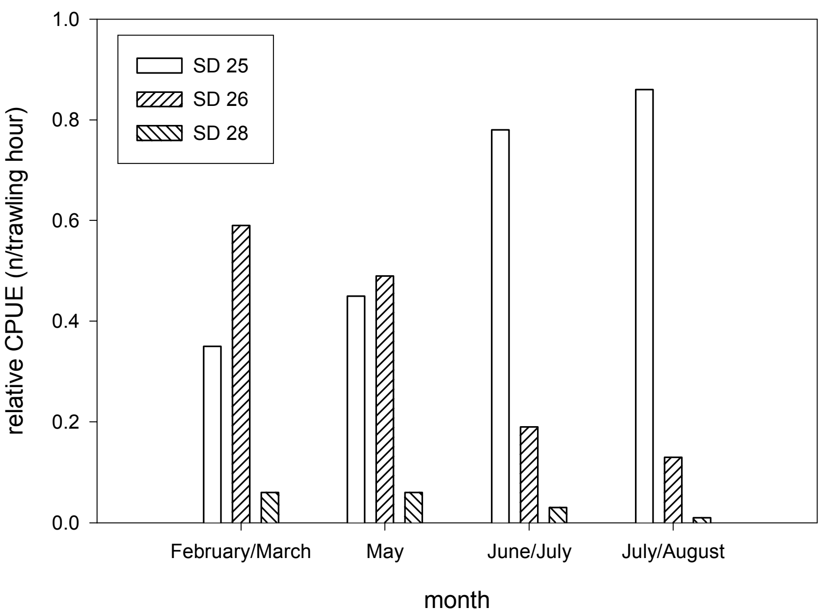


Fig. 1.1.62. Relative CPUE of the eastern Baltic cod spawning stock (maturity stages III-VIII) according to spawning area in various months of 1996.

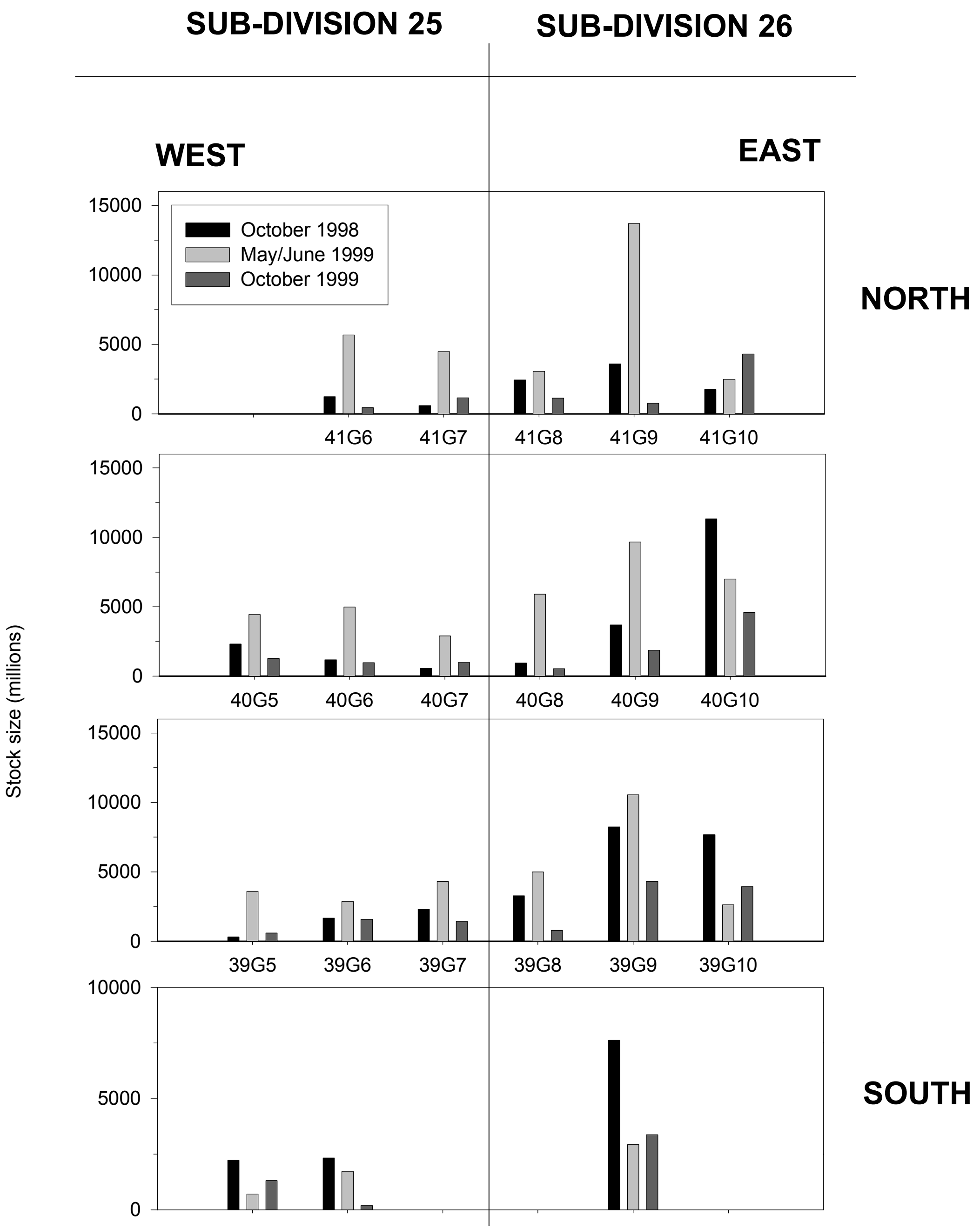


Fig. 1.1.63. Horizontal distribution (stock sizes per ICES statistical rectangle) of sprat 1+ in October 1998, and cod 2+ in May/June and October 1999 from hydroacoustic surveys.

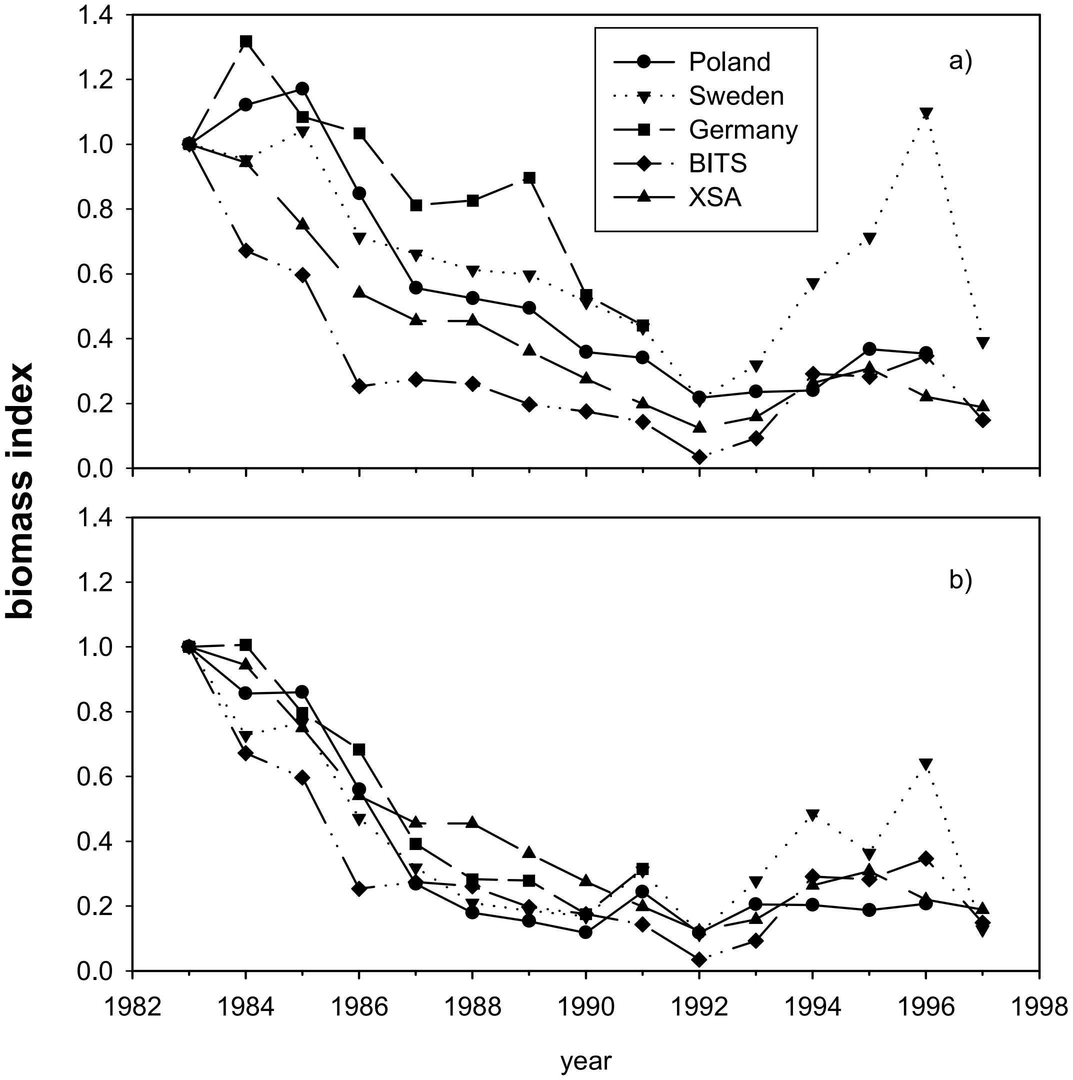


Fig. 1.1.64. Relative catch rates of cod by commercial national trawler fleets in the Central Baltic in comparison to catch rates of the Baltic International Trawl Survey (BITS) and stock biomass from standard XSA assessment (ICES, 2000); (a) uncorrected and (b) corrected for habitat areas affecting the catchability.

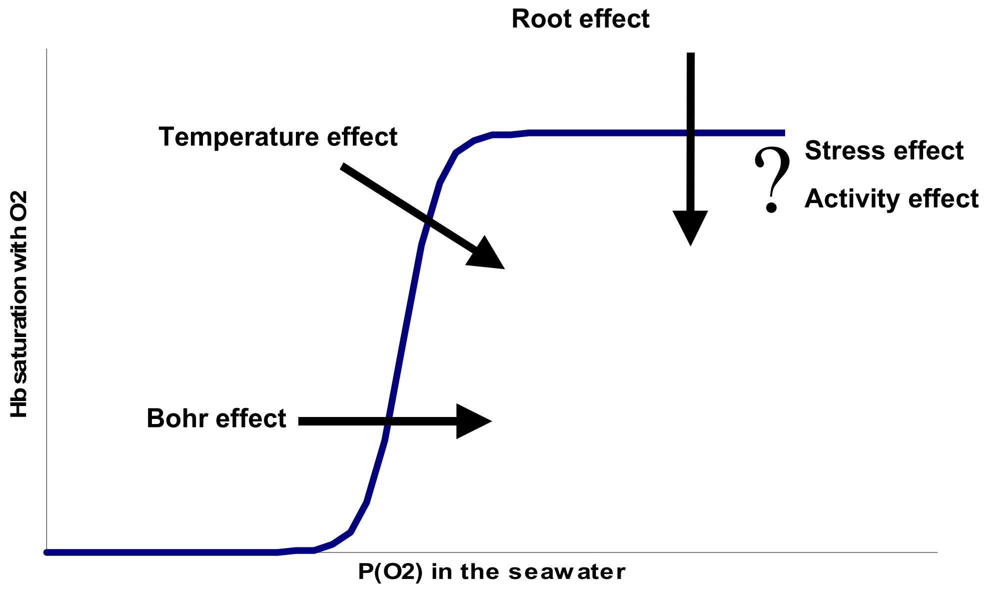


Fig. 1.1.65. Conceptual oxygen dissociation curve for the blood of living cod. The Bohr effect addresses the reduction in haemoglobin affinity for oxygen at decreasing pH, the Root effect the reduction in the oxygen carrying capacity of the blood at decreasing pH, while the temperature effect is increased oxygen requirement related to the increase of haemoglobin level and red cell surface area at increasing temperature (Randall 1970). Bauer and Rathschlag-Schaefer (1968) showed for mammalian blood that oxygen half saturation pressure (P50) was higher in the presence of cortisol or aldosterone in the blood. The stress hormone cortisol also occurs in cod blood. It is also not known how these effects work under different activity level of the living individual.

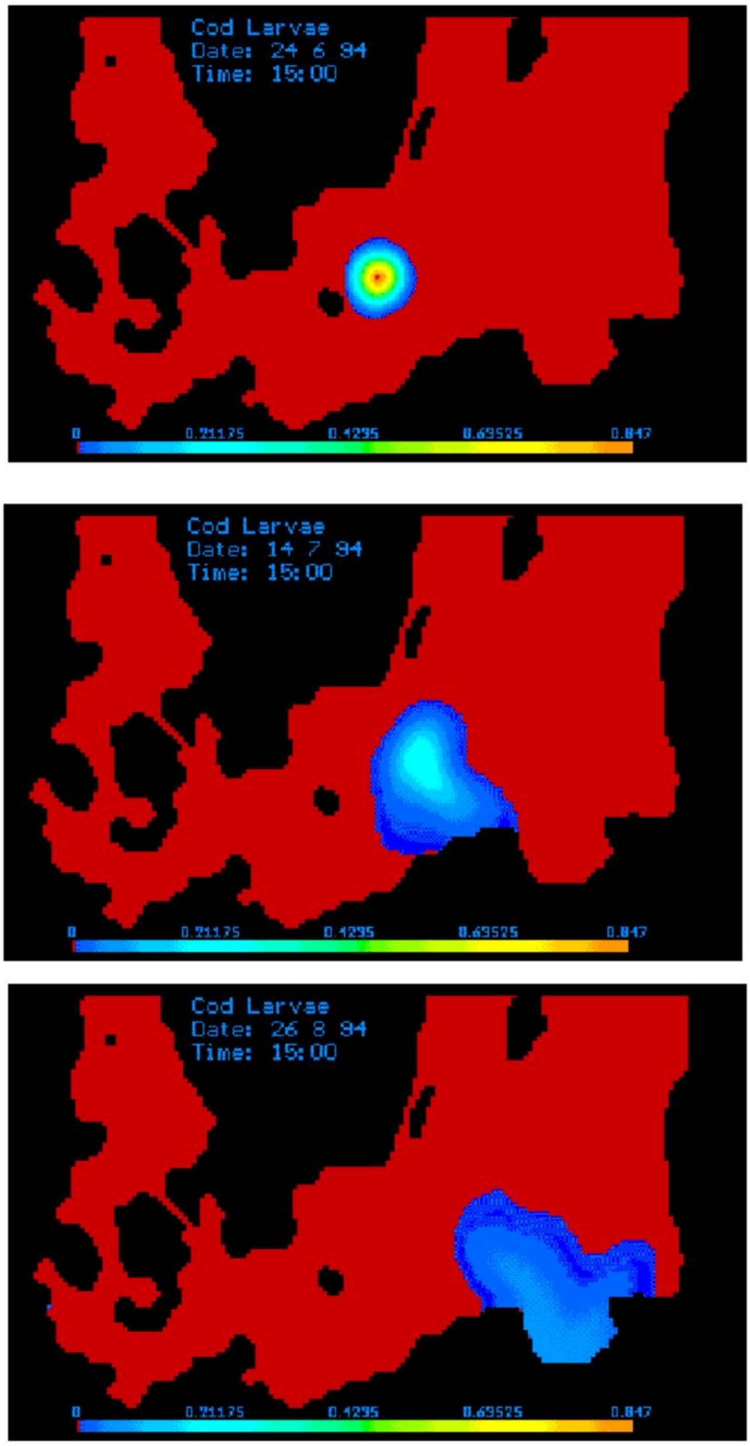


Fig. 1.1.66. Drift model simulation of the spatial distribution of cod larvae of the 1994 year class in the Eastern Baltic.

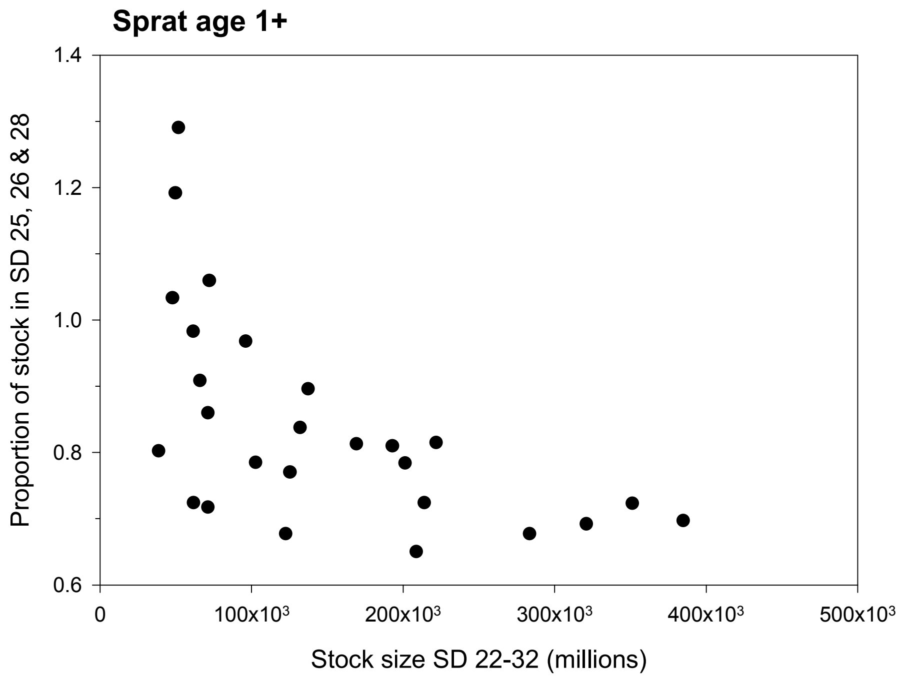


Fig.1.1.67. Stock size in Sub-divisons (SD) 22-32 (western + central MSVPA) vs. proprotion of stock in combined SD 25, 26 and 28 (area dis-aggregated MSVPA).

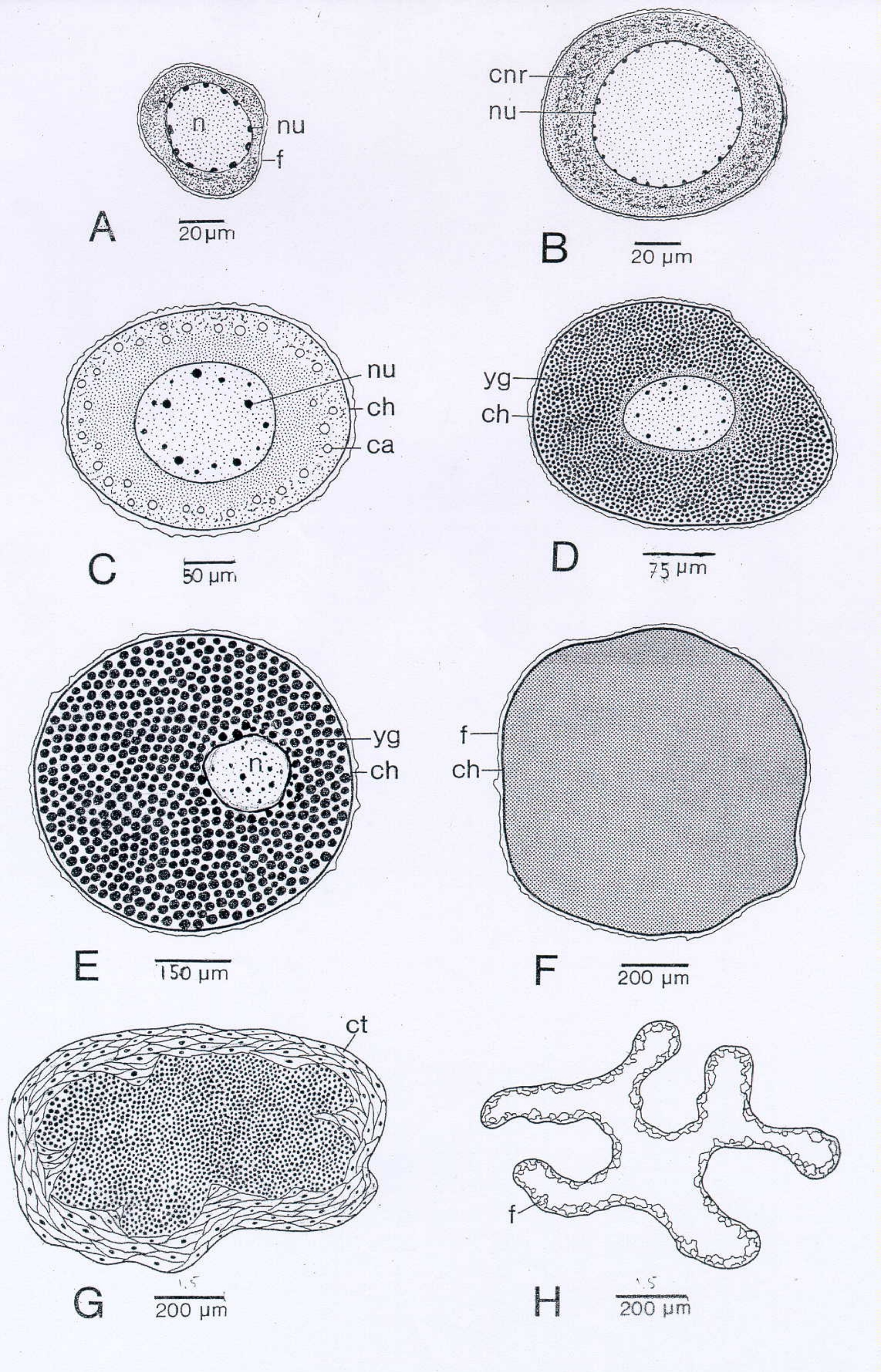
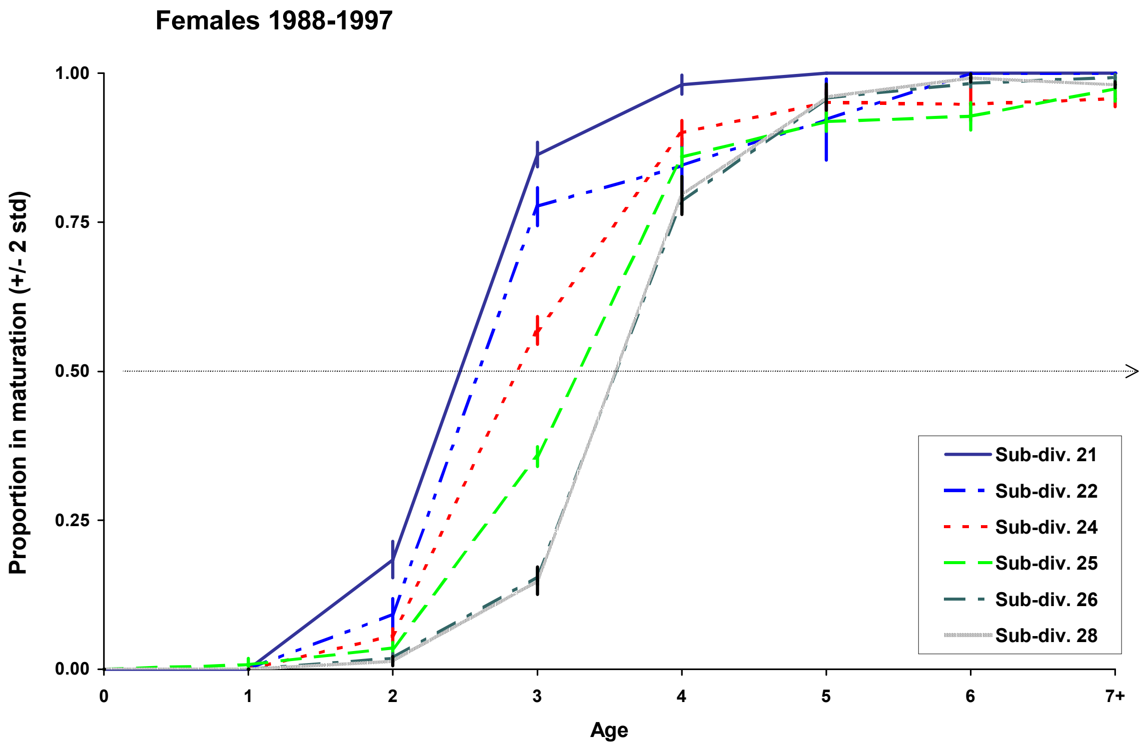


Fig. 1.2.1. Schematic drawing of histological characteristics in cod oogenesis. Primary growth phase: (A) Perinuclear stage oocyte with large circular nucleus and peripheral nucleoli. (B) Oocyte in circumnuclear ring stage, nucleus still with attached nucleoli. Second growth phase: (C) Oocyte with cortical alveoli, thin chorion, nucleus with detached nucleoli. (D) Vitellogenic oocyte with yolk granules filling most of cytoplasm, central large nucleus. (E) Vitellogenic oocyte with enlarged yolk granules, eccentric nucleus and advanced chorion. (F) Hydrated egg in follicle sac. (G) Fibrous capsule surrounding residual hydrated egg. (H) Post-ovulatory follicle. Measurements from paraplast sections. ca, Cortical alveoli; ch, chorion; cnr, circumnuclear ring; ct, connective tissue; f, follicle; n, nucleus; nu, nucleolus; yg, yolk granules. (From Tomkiewicz et al. 2003).



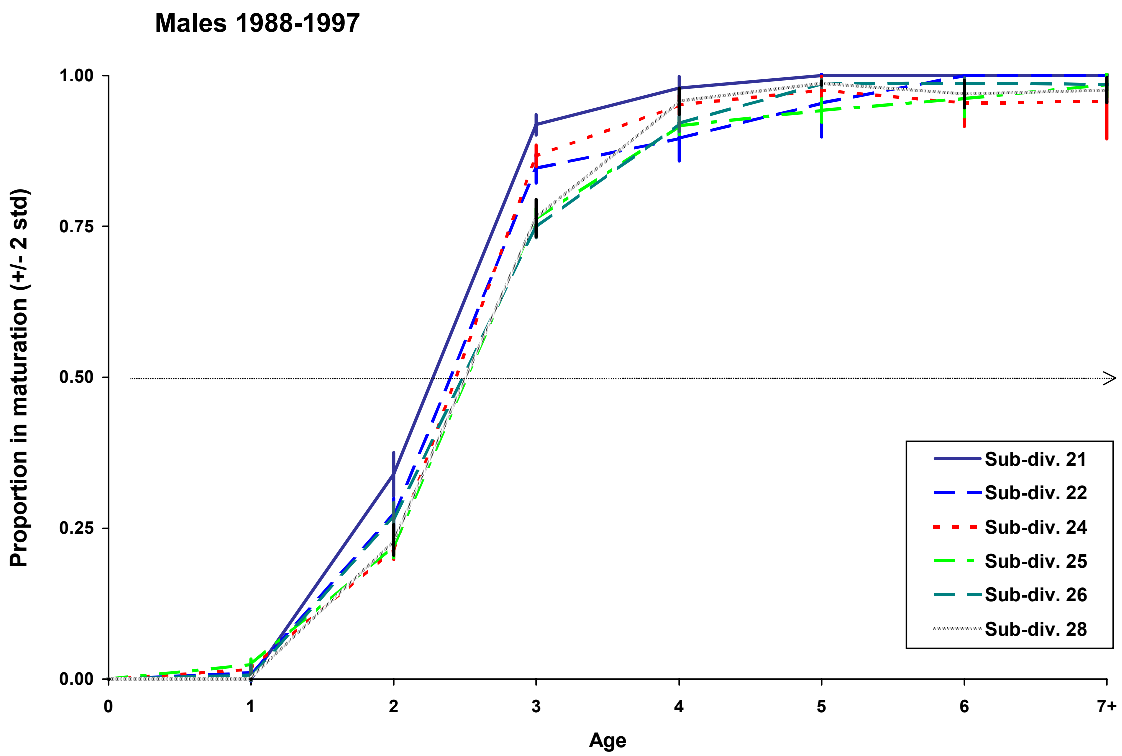


Fig. 1.2.2. Average female and male maturity ogives of cod derived from the maturity database stablished from national data obtained in relation to BITS (Baltic International Trawl Survey).

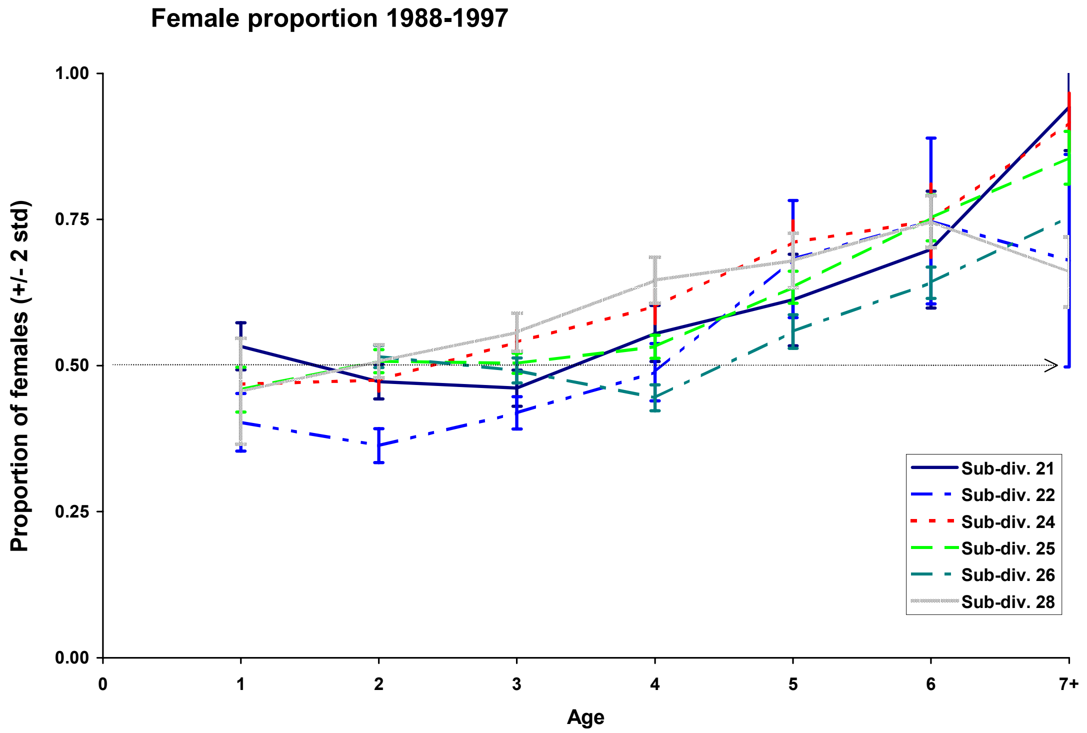


Fig. 1.2.3. Average sex ratio of cod in the stock derived from the maturity database established from national data obtained in relation to BITS (Baltic International Trawl survey).

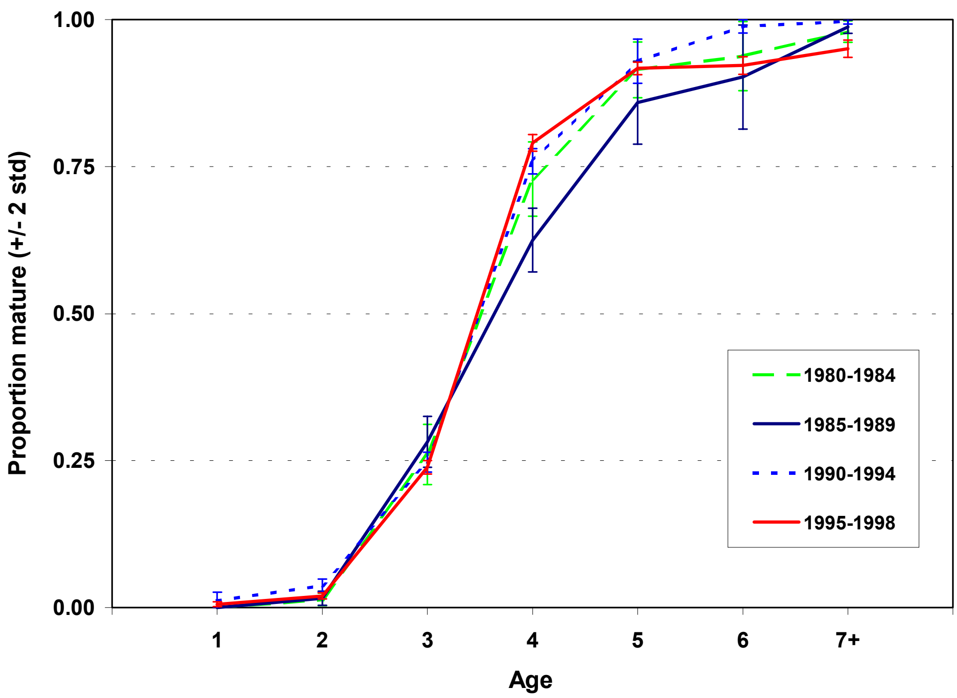


Fig. 1.2.4. Average proportion of mature cod females at age during different time periods in Sub-division 25 based on data from the project related maturity database.

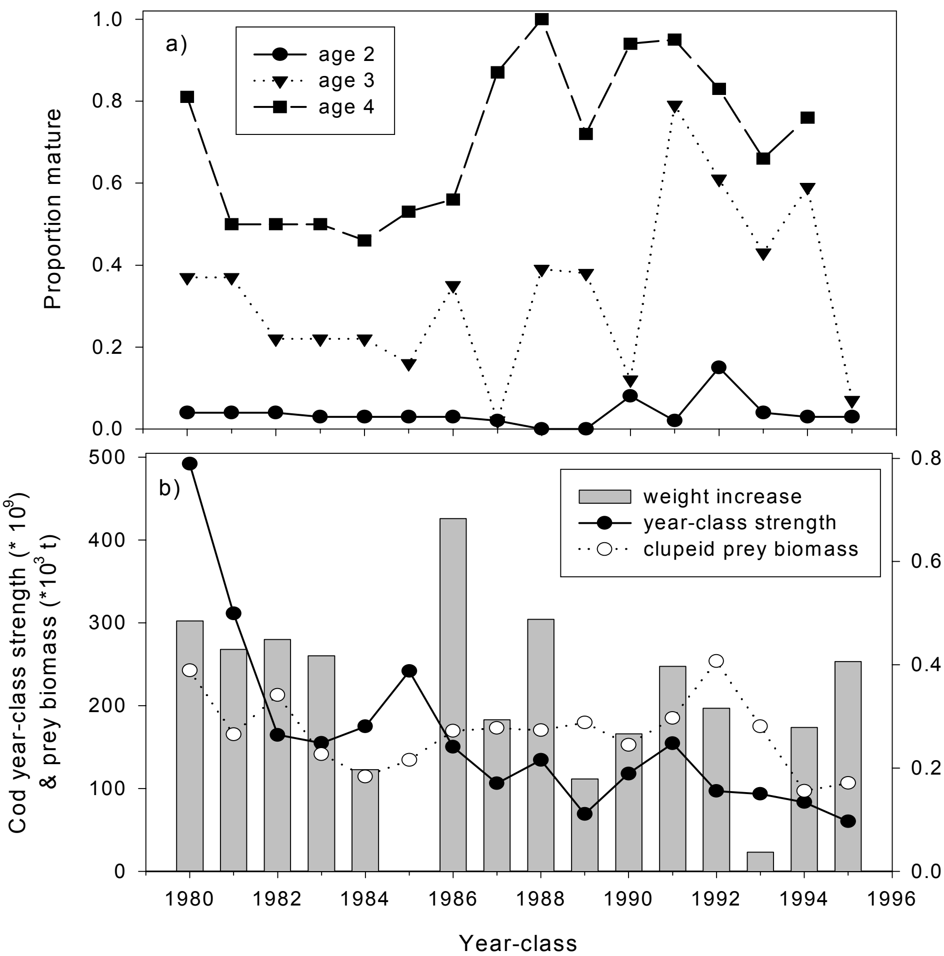


Fig.1.2.5. (a) Average proportion of female cod attaining sexual maturity at age 2, 3 and 4 for the year-classes 1980-95 (for years 1982-84 and 1985-87 averages otherwise yearly data applied) in Sub-division 25; (b) cohort strength at age 1 of year-classes 1980-95, clupeid prey availability (biomass of sprat and juvenile herring in autumn of years where cod cohorts were 3 years old) and weight increase from mid of 3rd to mid of 1st quarter of 3 to 4 year old cod (data Tomkiewicz unpubl. and Köster et al. 2001a).

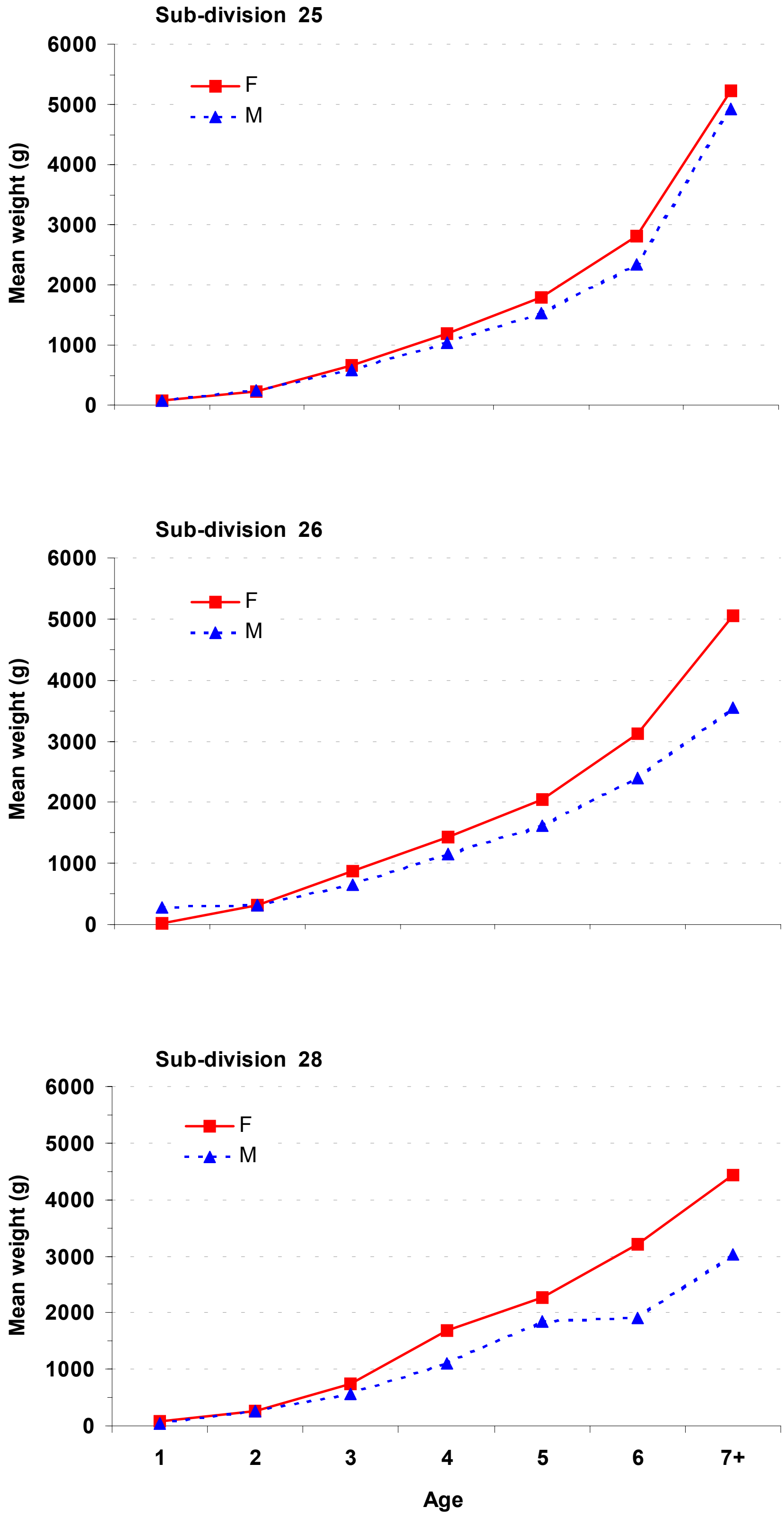


Fig.1.2.6. Average weight at age for female and male cod in different Sub-divisions for the time period 1989-98 based on Swedish, German and Danish surveys in March (BITS).

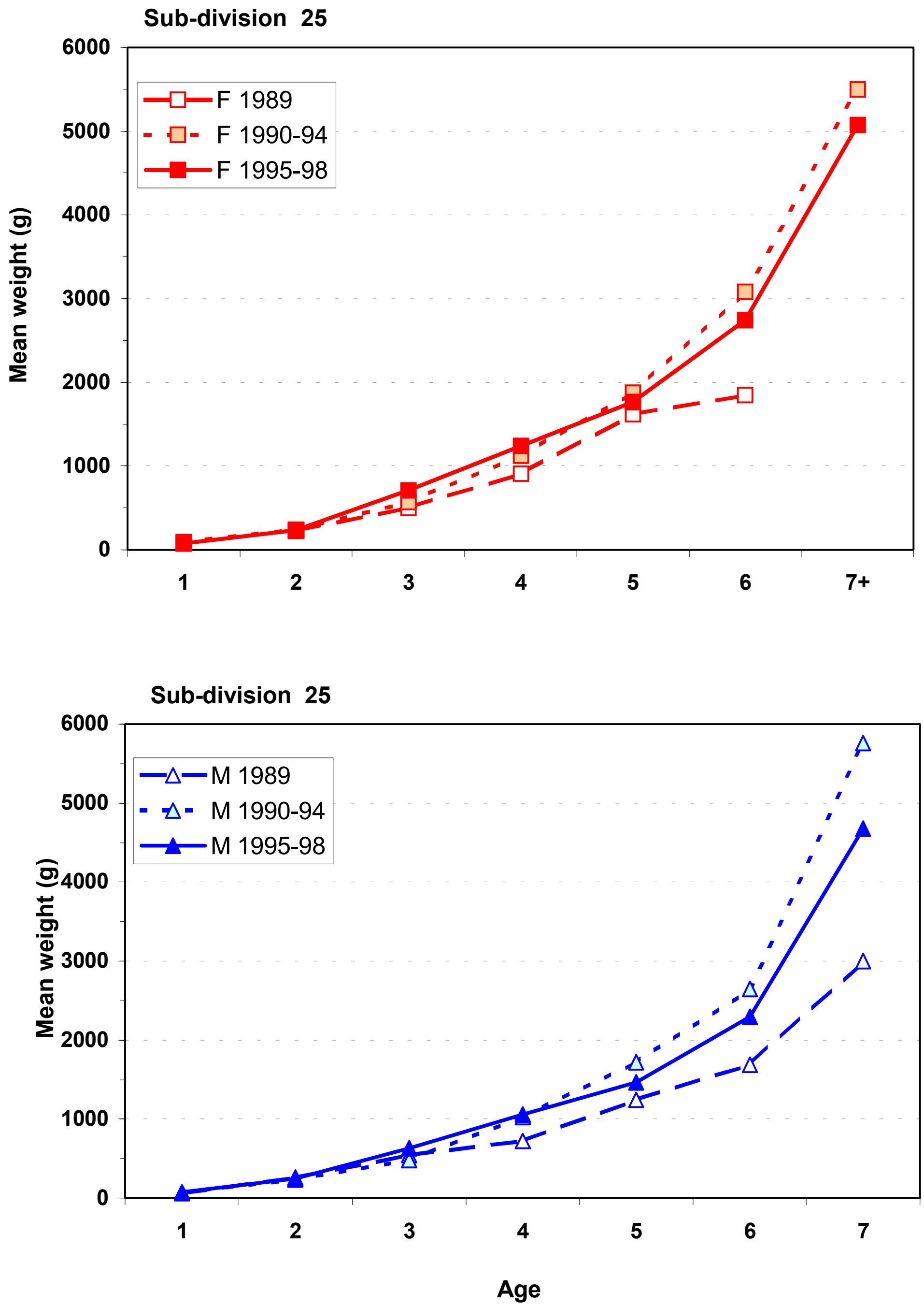


Fig. 1.2.7. Average weight at age for female and male cod in Sub-division 25 in different time periods based on Swedish, German and Danish surveys in March (BITS).

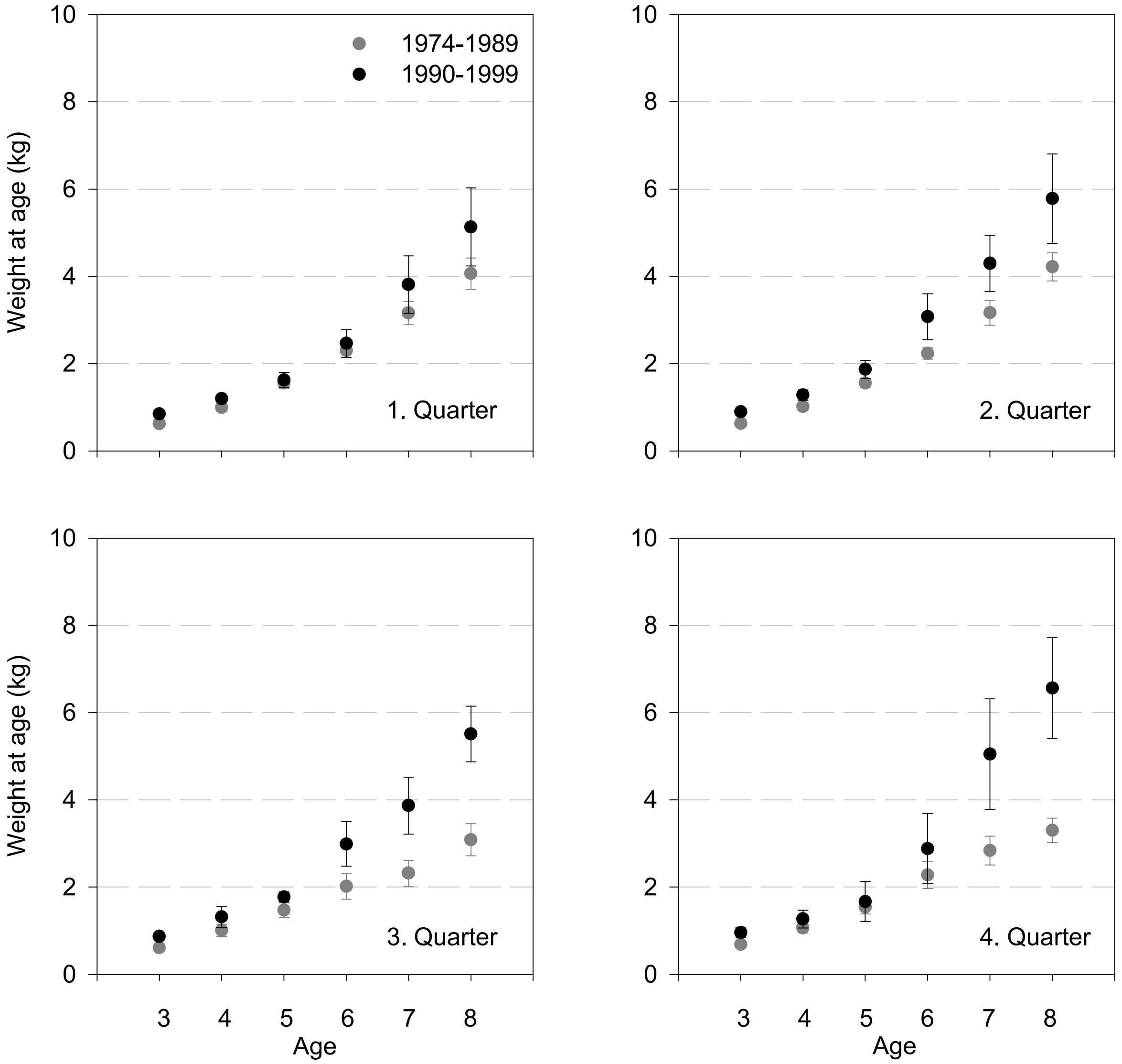


Fig. 1.2.8.a. Weight at age of cod in SD 25 for the periods from 1974-1989 and 1990-1999. Dots represent means, bars indicate the standard error.

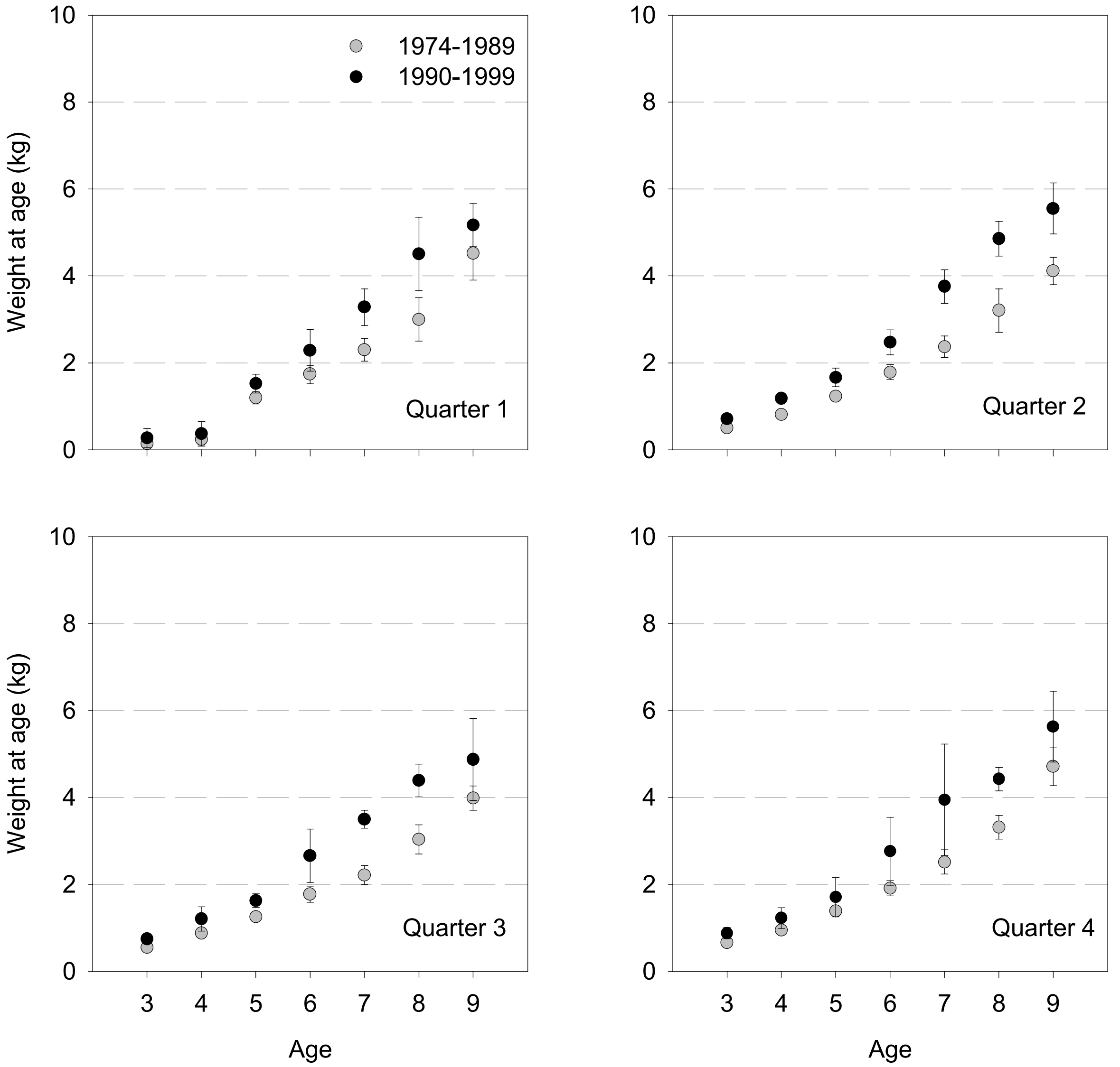


Fig. 1.2.8.b. Weight at age of cod in SD 26 for the periods from 1974-1989 and 1990-1999. Dots represent means, bars indicate the standard error.

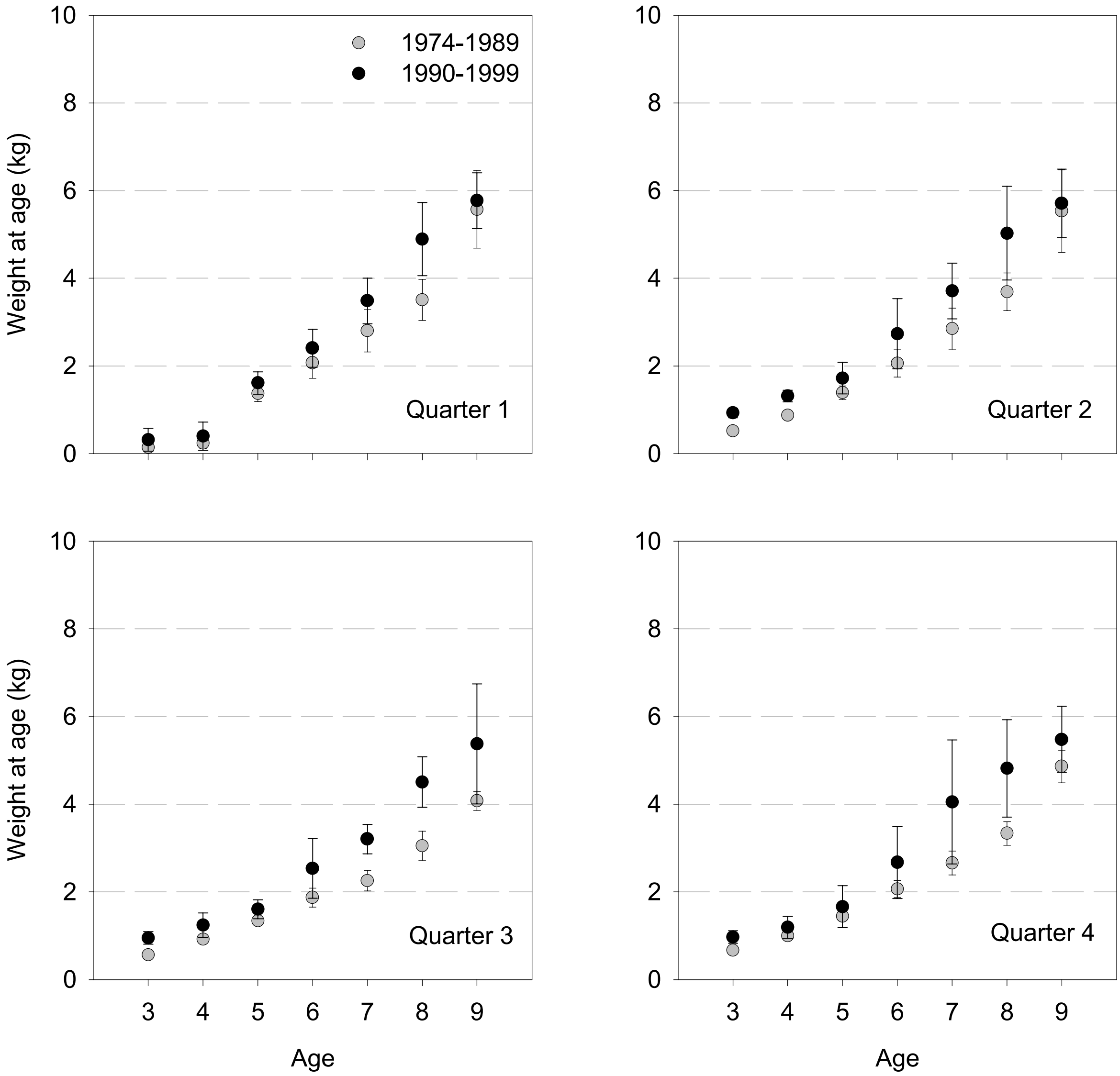


Fig. 1.2.8.c. Weight at age of cod in SD 28 for the periods from 1974-1989 and 1990-1999. Dots represent means, bars indicate the standard error.

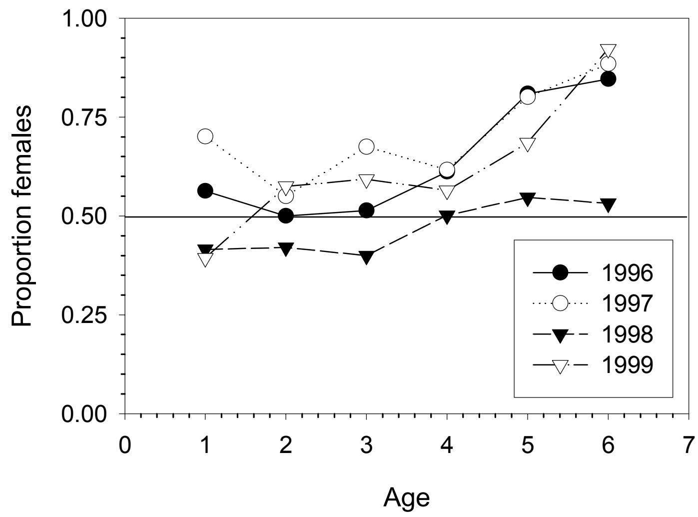


Fig. 1.2.9. Sex ratios of sprat at age in Sub-divisions 26 from commercial sampling in the 1. quarter and pelagic trawl surveys in the 2. quarter 1996-1999.

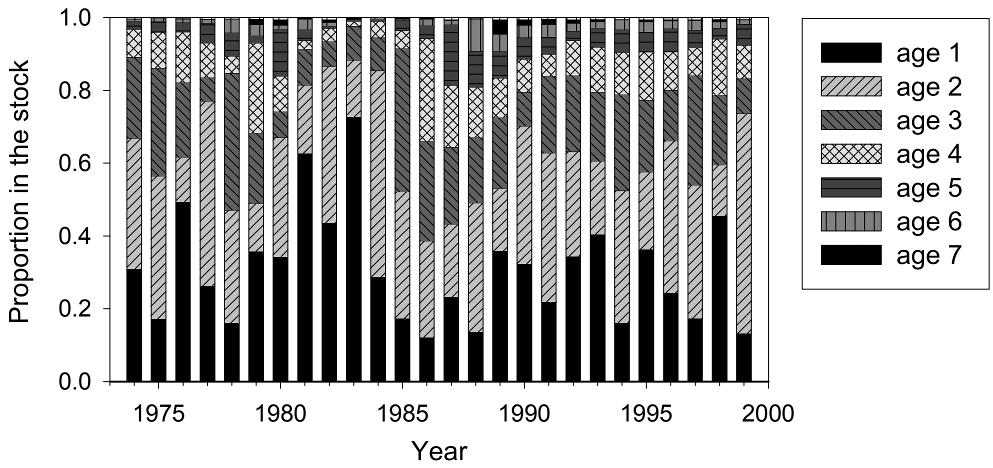


Fig. 1.2.10. Proportion different sprat age-groups contribute to the stock biomass in Sub-division 26 during spawning time 1974-1999.

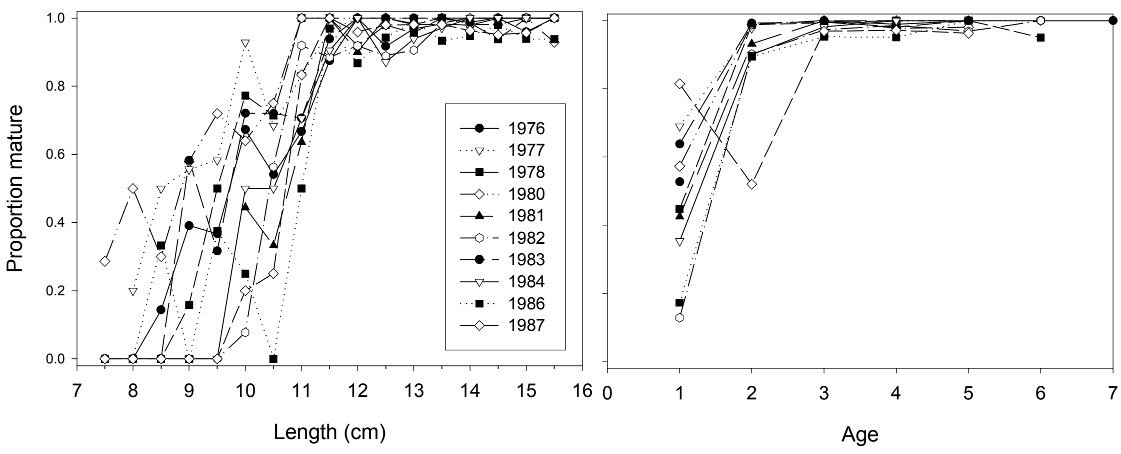


Fig. 1.2.11. Proportion mature sprat in different length (a) and age-groups (b) from Sub-division 25 in April-June 1976-1987 (data from ICES 2001d).

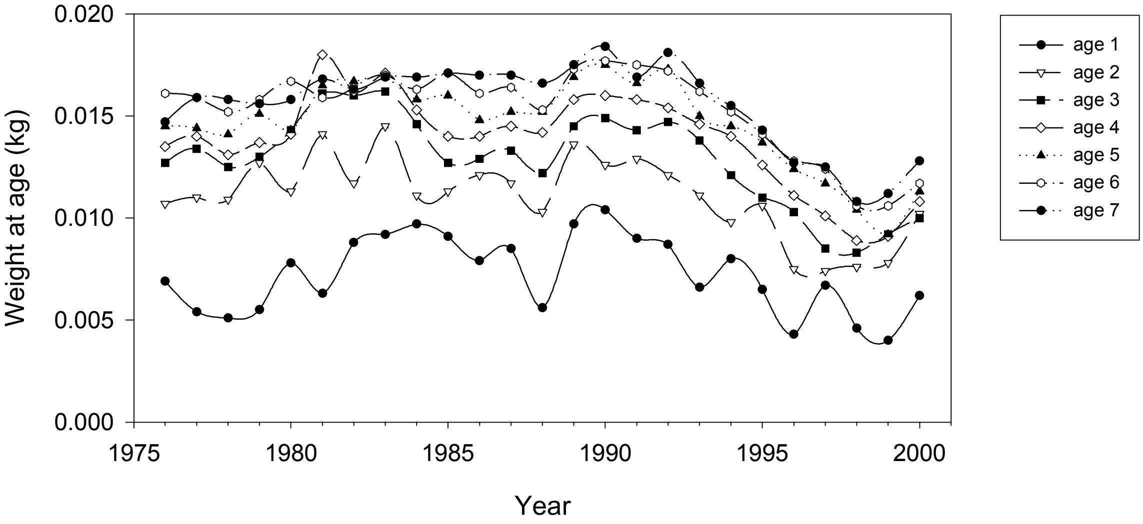


Fig. 1.2.12. Average weight at age of sprat in the central Baltic (1.quarter) as obtained from sampling of the commercial fishery.

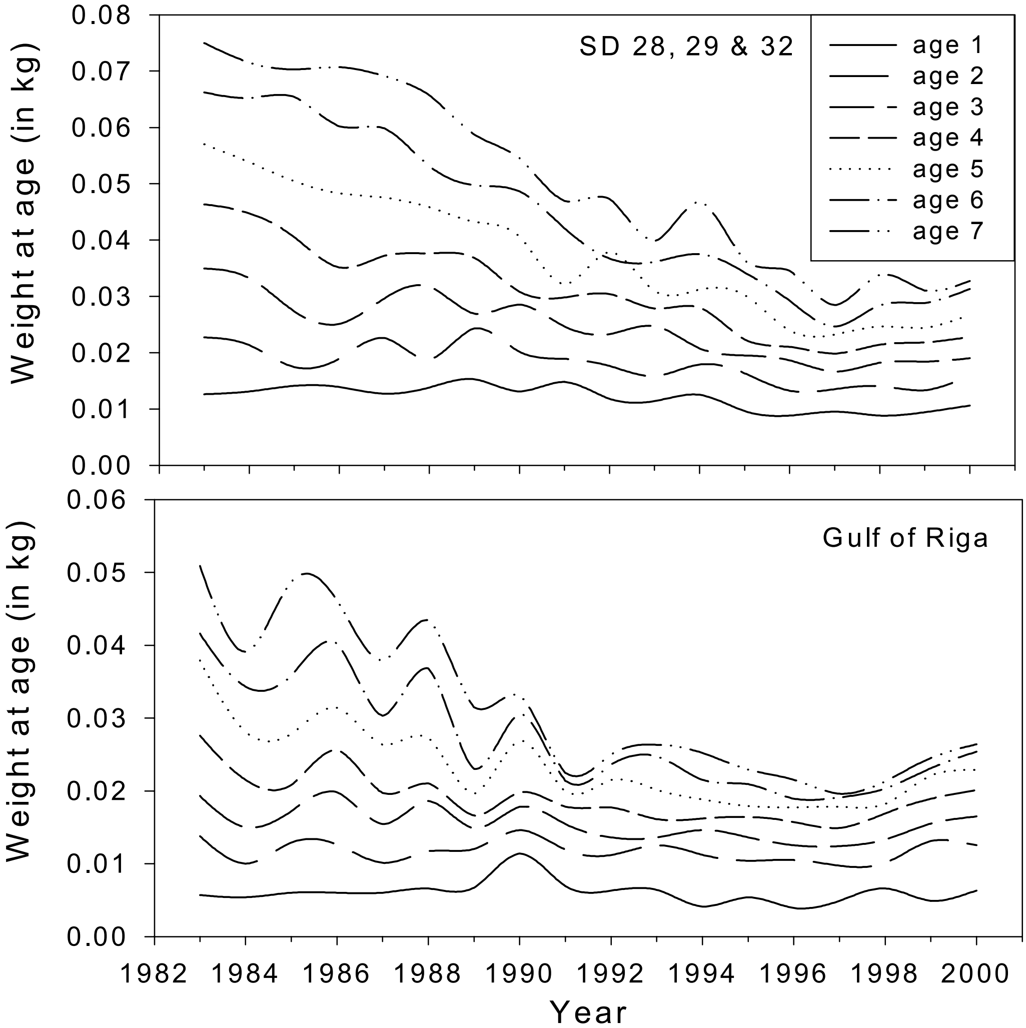


Fig. 1.2.13. Average weight at age of herring (1.quarter) as obtained from sampling of the commercial fishery in the Central Baltic and the Gulf of Riga.

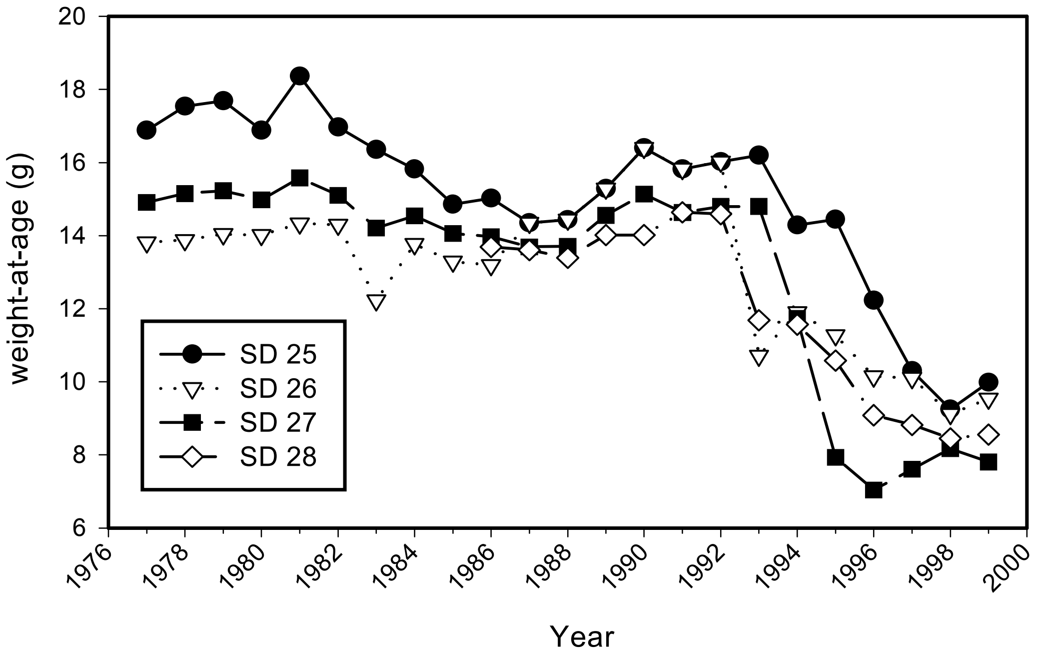


Fig. 1.2.14. Average weight at age of sprat (1. quarter) in different Sub-divisions of the Central Baltic.

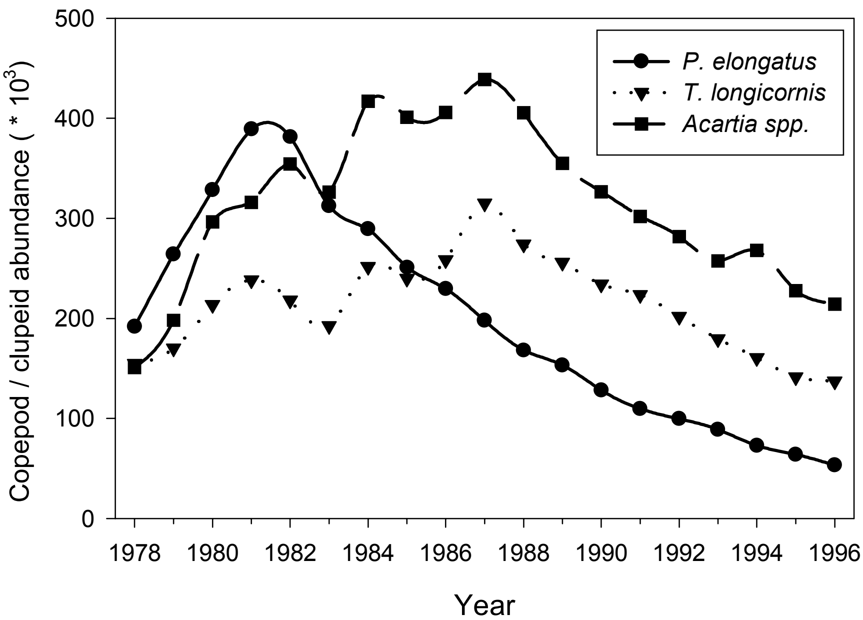


Fig. 1.2.15. Major copepod species prey availability per predator abundance (sprat and herring) in the Central Baltic Sea; spline smoothing applied.

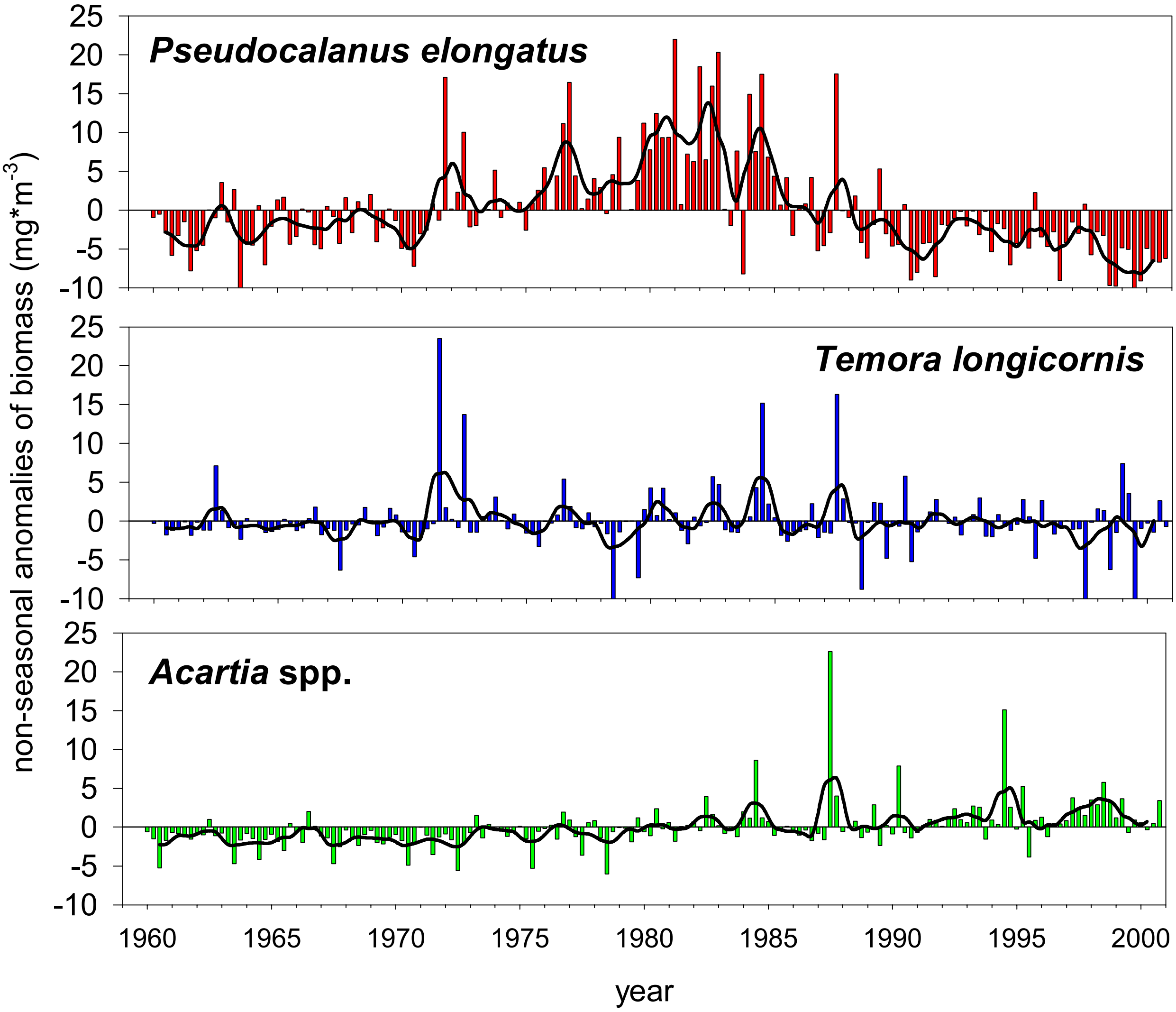


Fig. 1.2.16. Time series of dominating calanoid copepod biomass in the Central Baltic as non seasonal anomaly.

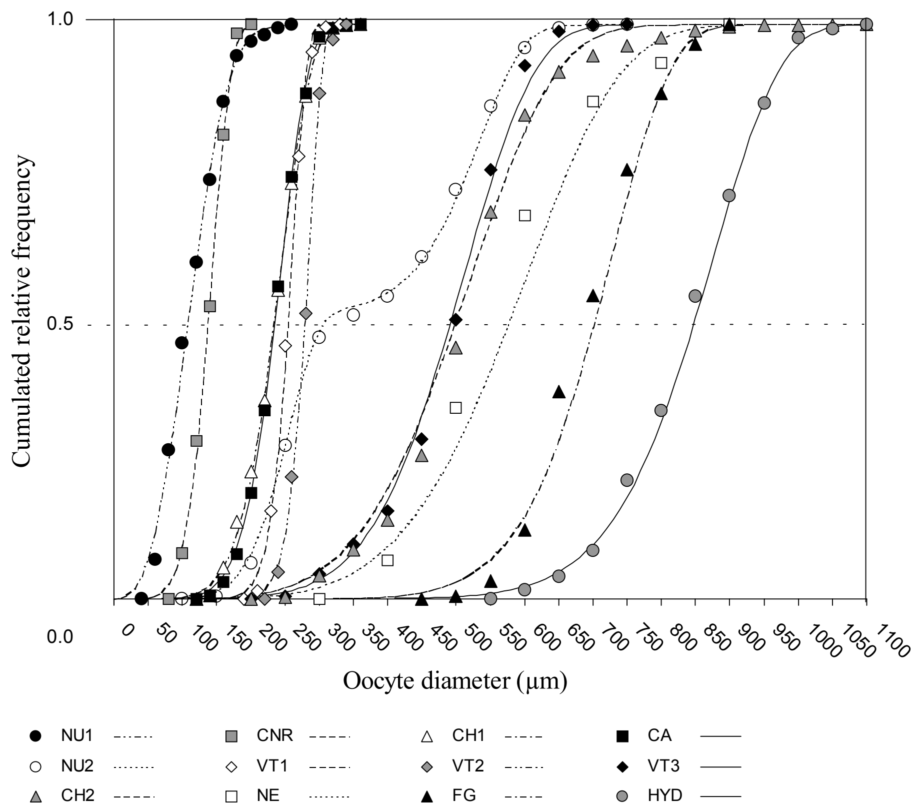


Fig. 1.2.17. Cumulated size frequency distributions of cod oocytes with different histological characters (measurements from paraplast sections). The symbols for each character represent the cumulated frequencies per size interval and the lines fitted Weibull (1951) functions: $f(x,\alpha,\beta)=1-e^{-(x/\beta)^{\alpha}}$.

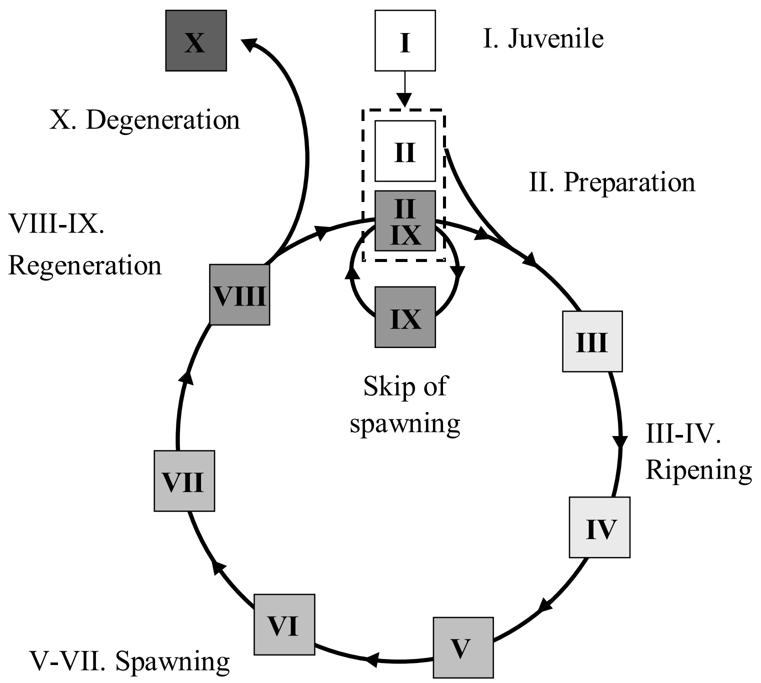


Fig. 1.2.18. Maturity stages combined into six reproductive phases: Juvenile, Preparation, Ripening, Spawning, Regeneration and Degeneration based on histological features.

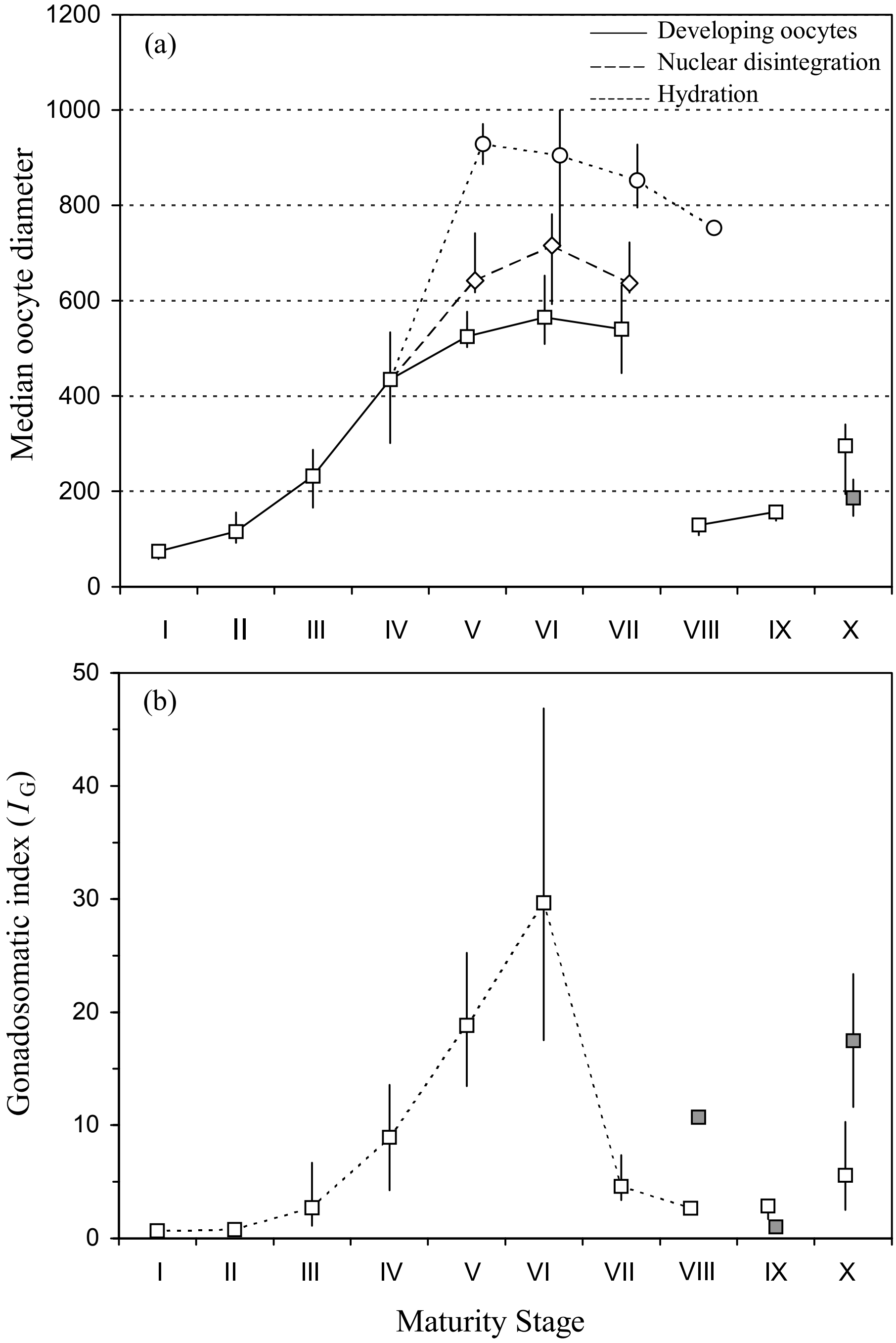


Fig. 1.2.19. Variation in (a) median oocyte diameter (in µm) and (b) gonadosomatic index, $I_{G,}$ of ovaries in relation to histological maturity stages. The symbols relate to the medians and the bars to the range between the 0.05 and 0.95 percentiles. Filled squares refer to: Stage VIII, ovaries with atresia; Stage IX: skip of spawning; Stage X: Xb (open square: Xa).

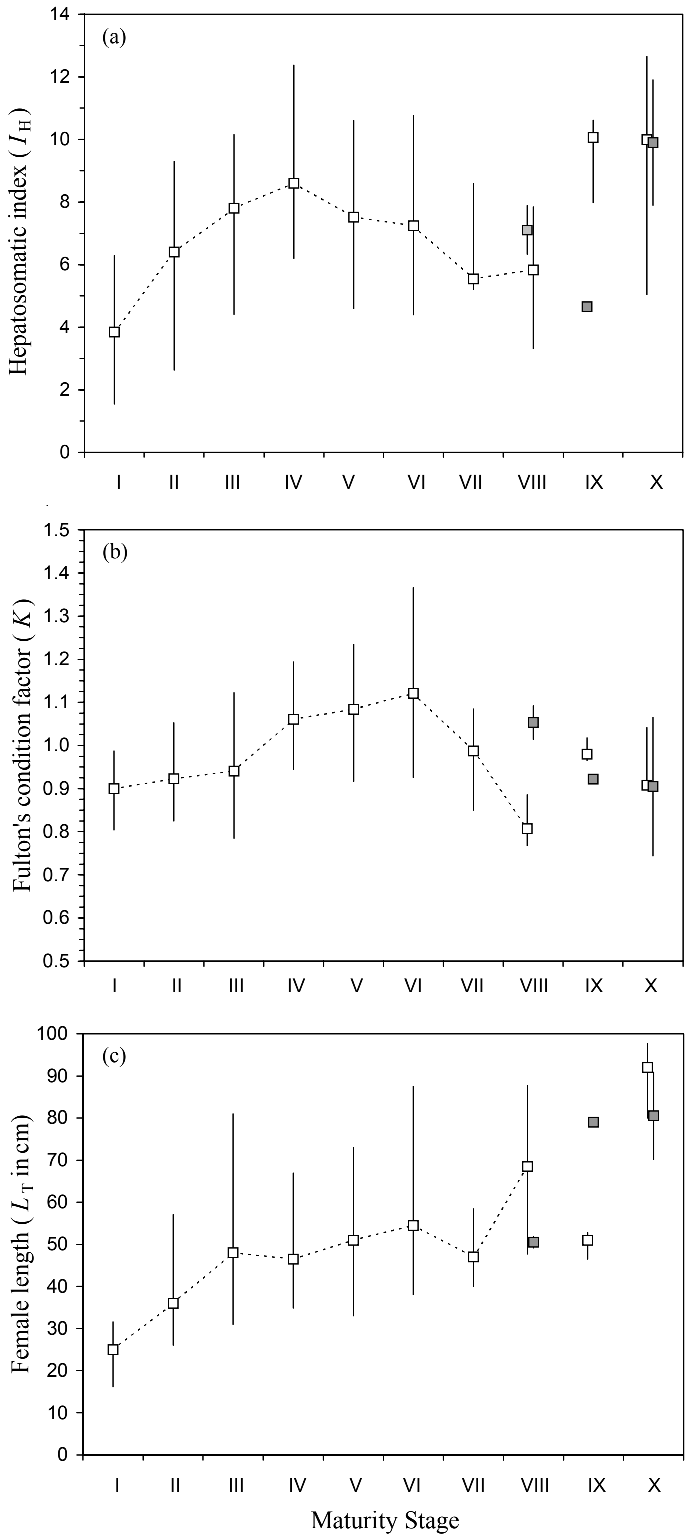


Fig. 1.2.20 Variation in cod (a) hepatosomatic index, I_H, (b) Fulton's condition factor, K and (c) total length, L_T, of sampled females in relation to histological maturity stage. Symbols identify medians and bars 0.05-0.95 percentiles. Filled squares refer to: Stage VIII, ovaries with atresia; Stage IX: skip of spawning; Stage X: Xb (open square: Xa).

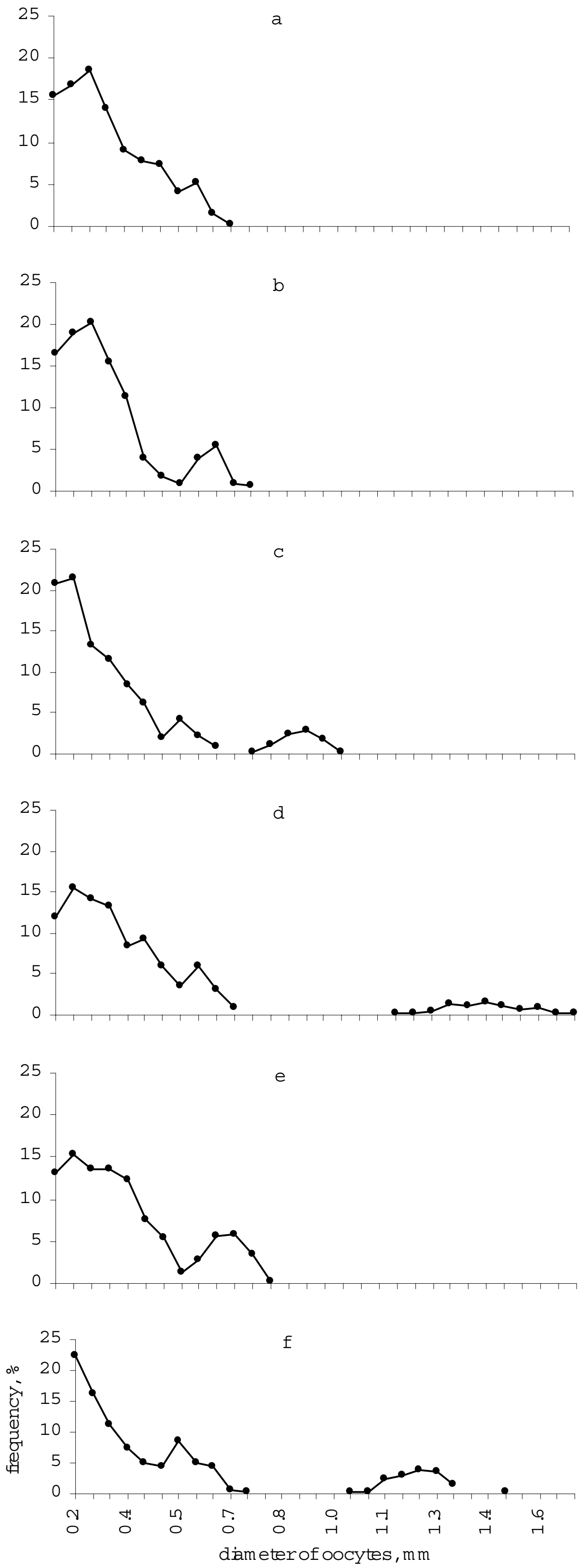


Fig. 1.2.21. Size frequency distribution of vitellogenic and maturing oocytes in sprat ovaries of different stages.

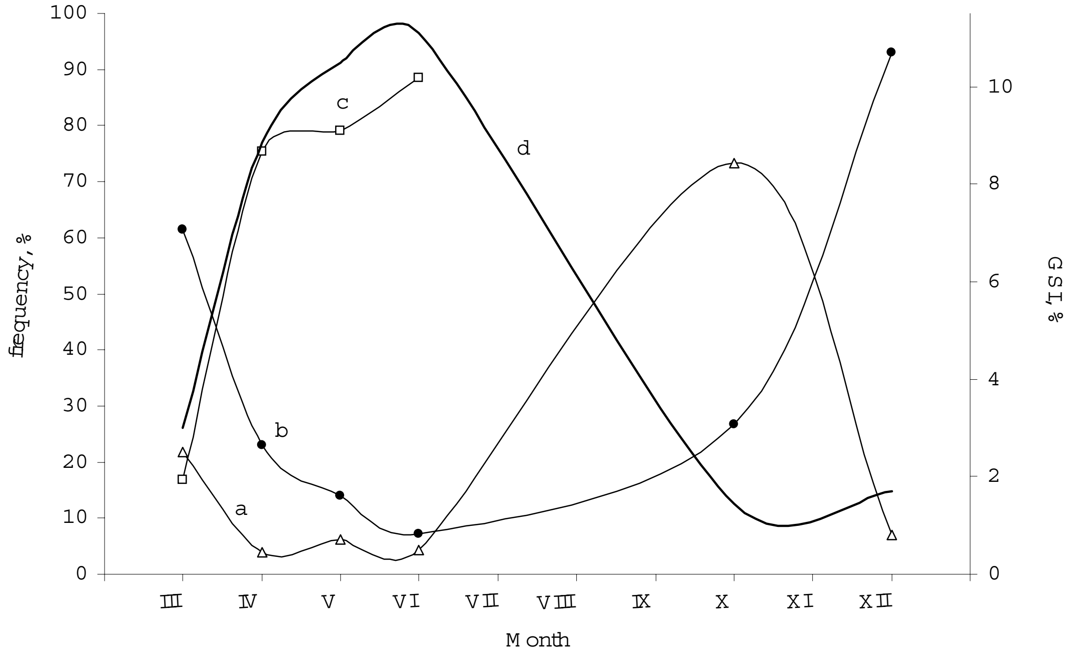


Fig. 1.2.22. Relative quantity of sprat female with immature (a), maturing (b), ripe (c) ovaries, and average value GSI of ovary (d) by month.

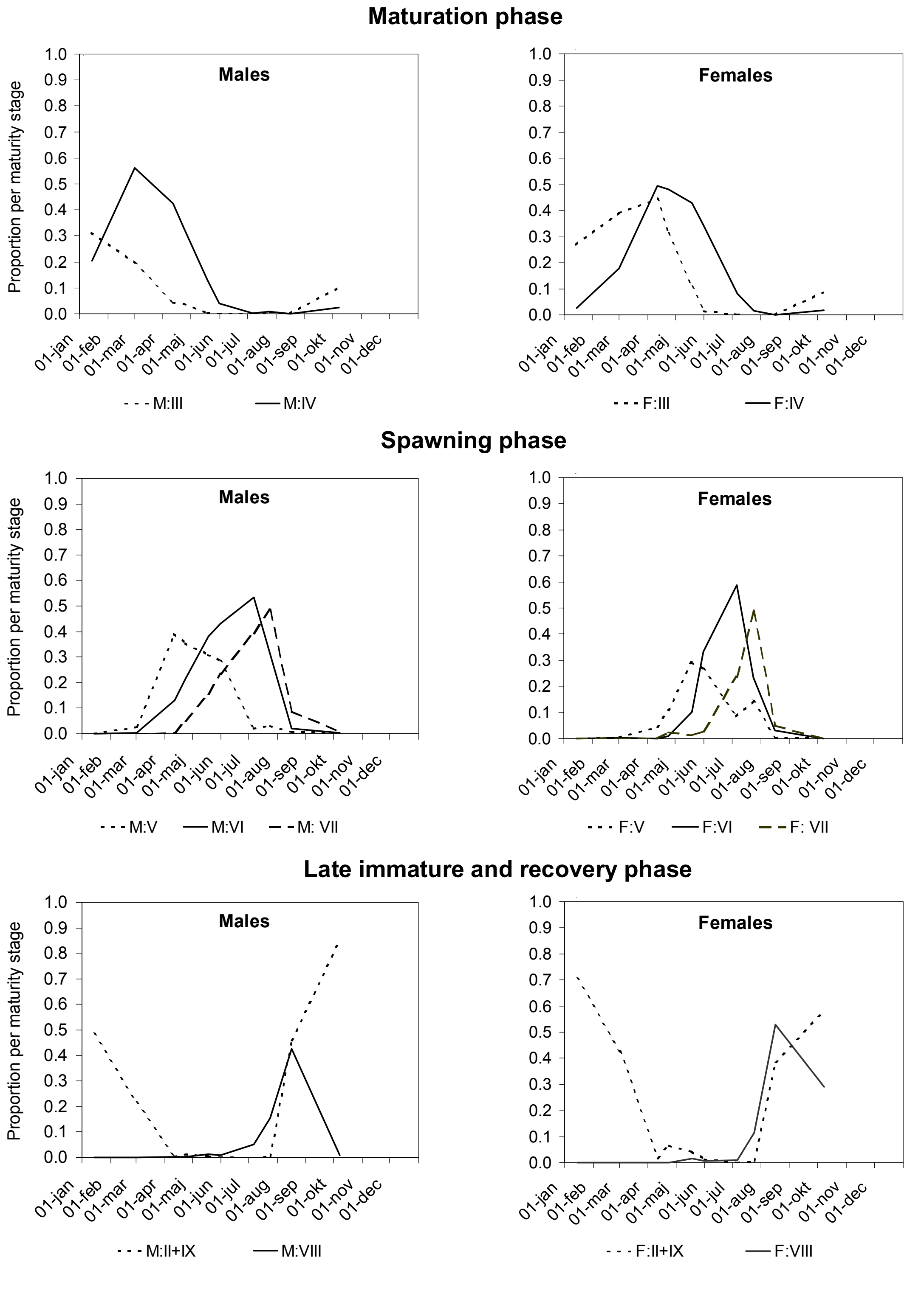
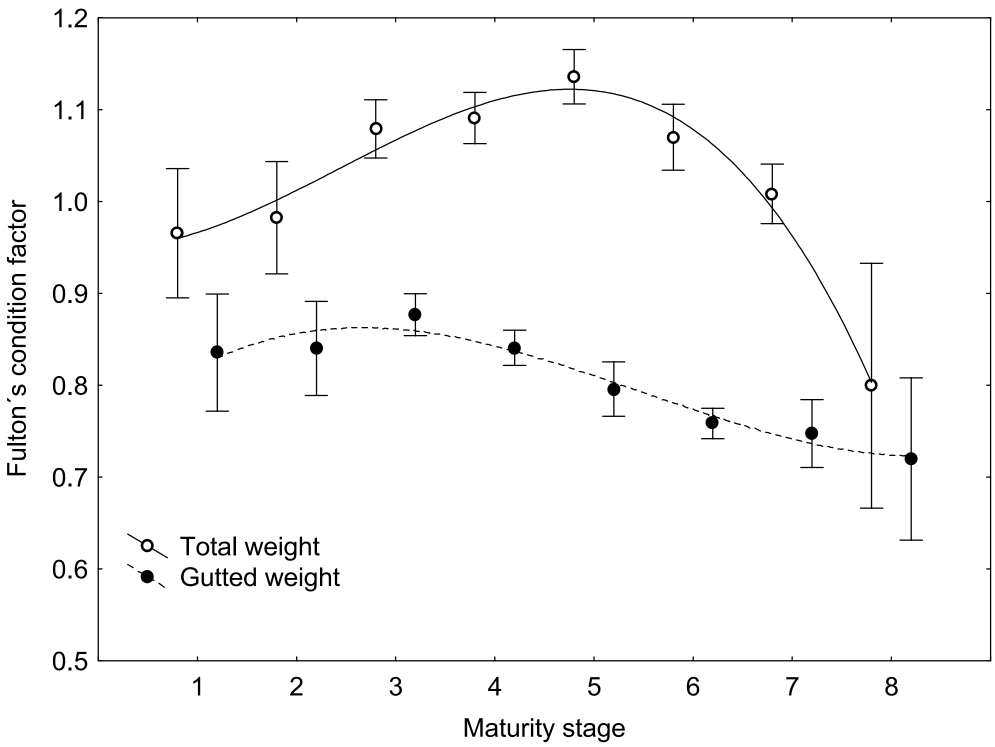


Figure 1.2.23. Average cod male and female proportions in different stages and phases of the reproductive cycle based on the CPUE of stages II-IX during the years 1995-97.



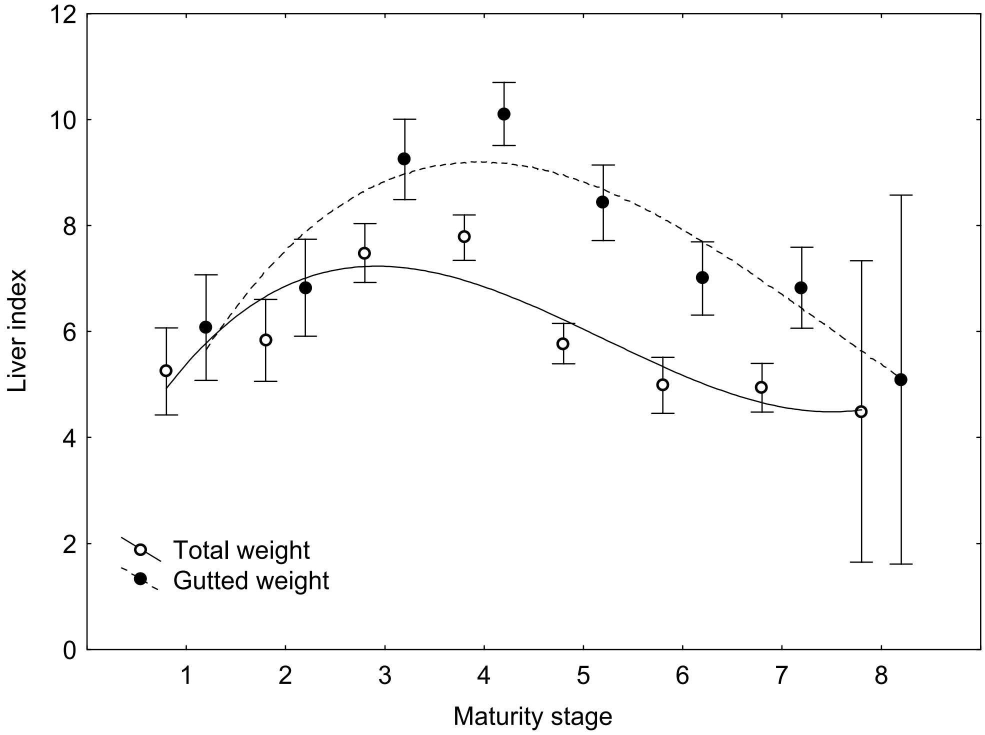


Fig. 1.2.24. Variability of Fultons condition index and liver index of Baltic cod in relation to maturity stage (determined histologically). Both indices have been calculated using total and gutted weight respectively. Data are from surveys in 2000.

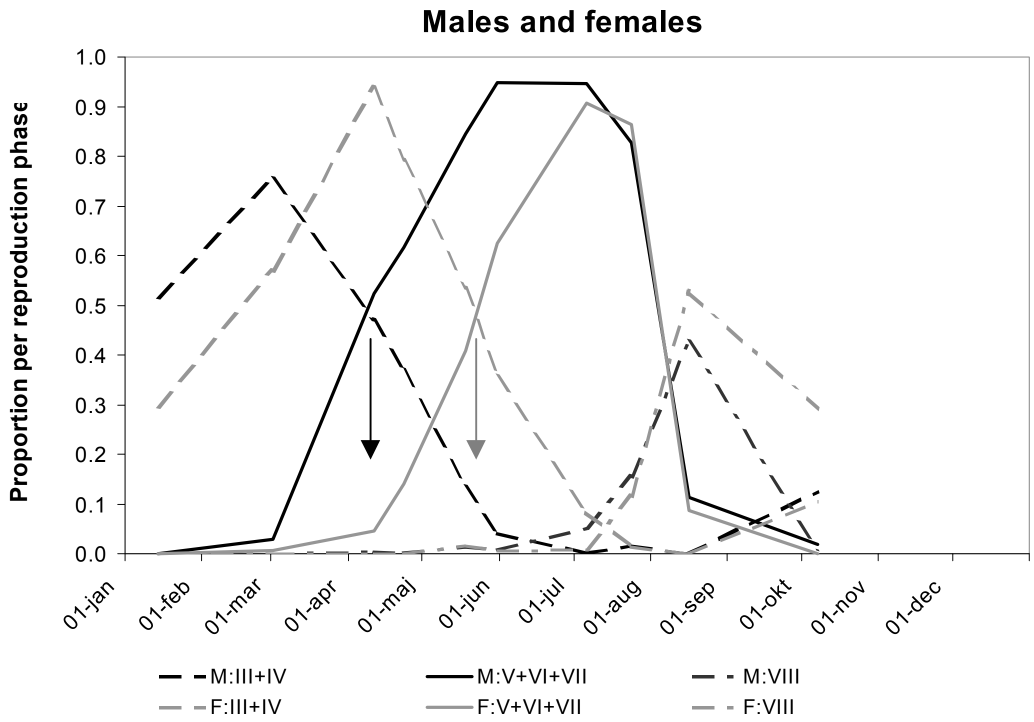


Figure 1.2.25. Average proportion and timing of the cod maturing stages (III-IV), spawning stages (V-VII) and spent stage (VIII) for males and females during the years 1995-97. Late immature and resting stages (II and IX) are included in the calculation of the proportions, but not illustrated in the figure. The arrows indicate the time when 50% of the female or male cod have entered spawning condition, respectively.

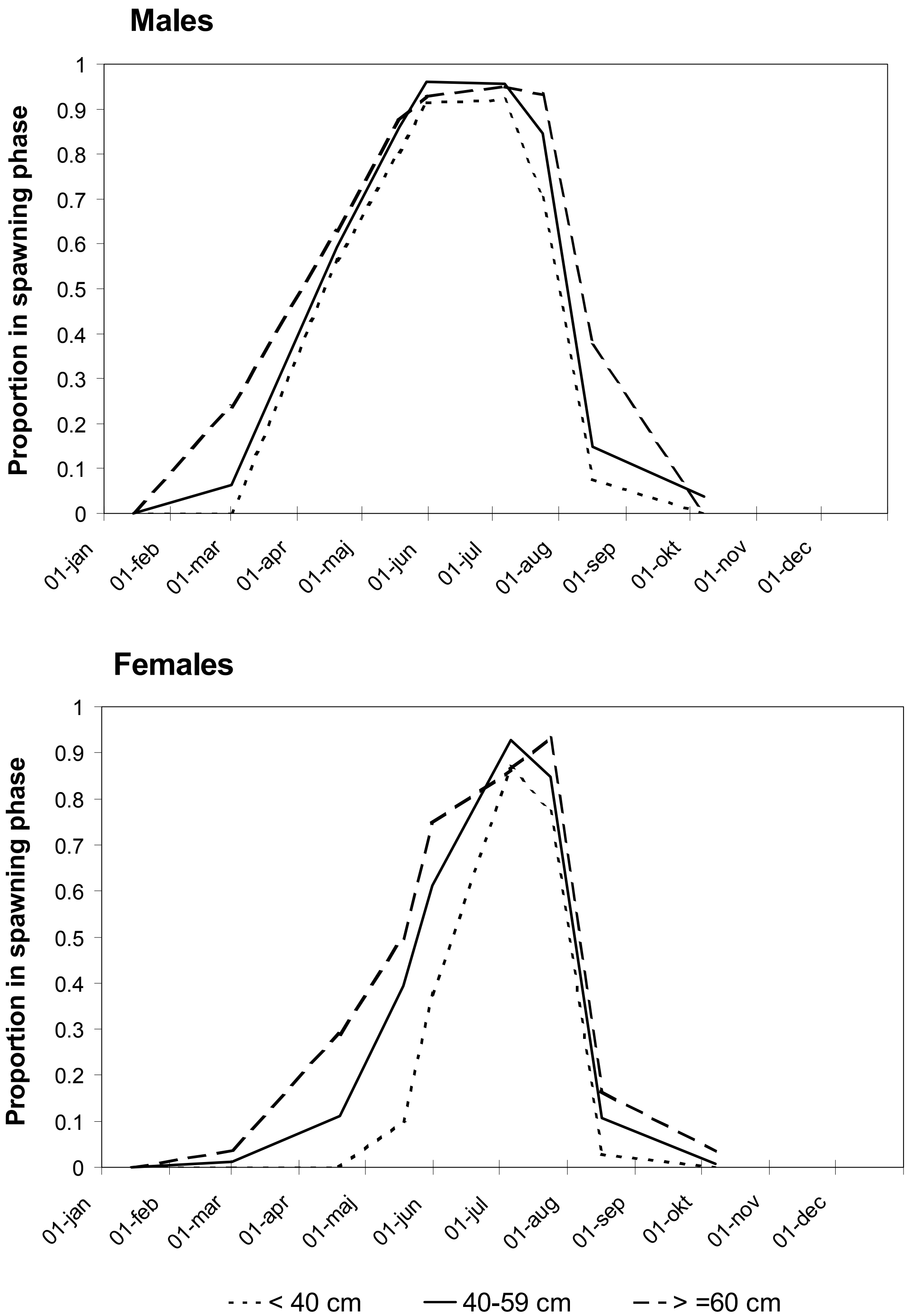


Fig. 1.2.26. Average proportion of female and male cod in spawning phase (stages V-VII) for different size groups during the years 1995 and 1997. The proportions relate to the CPUE of stage II-IX.

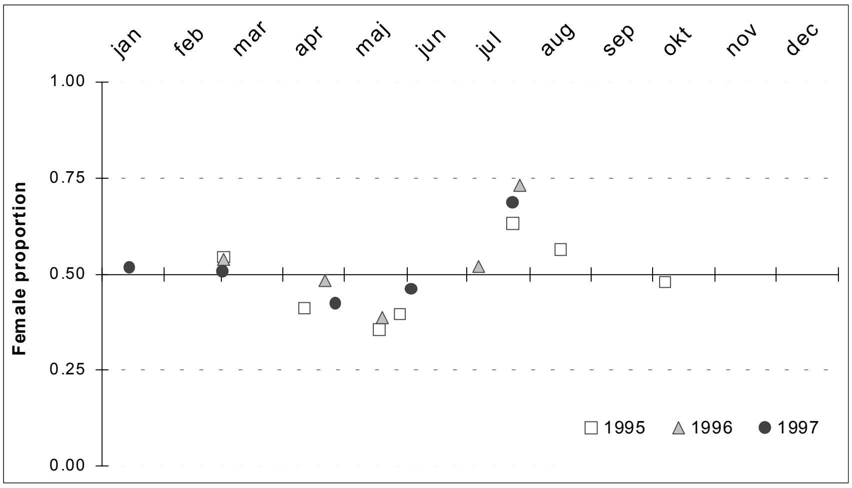


Figure 1.2.27. Proportion of cod females in the catches based on the average CPUE of cod larger than 15 cm during surveys in 1995-1997.

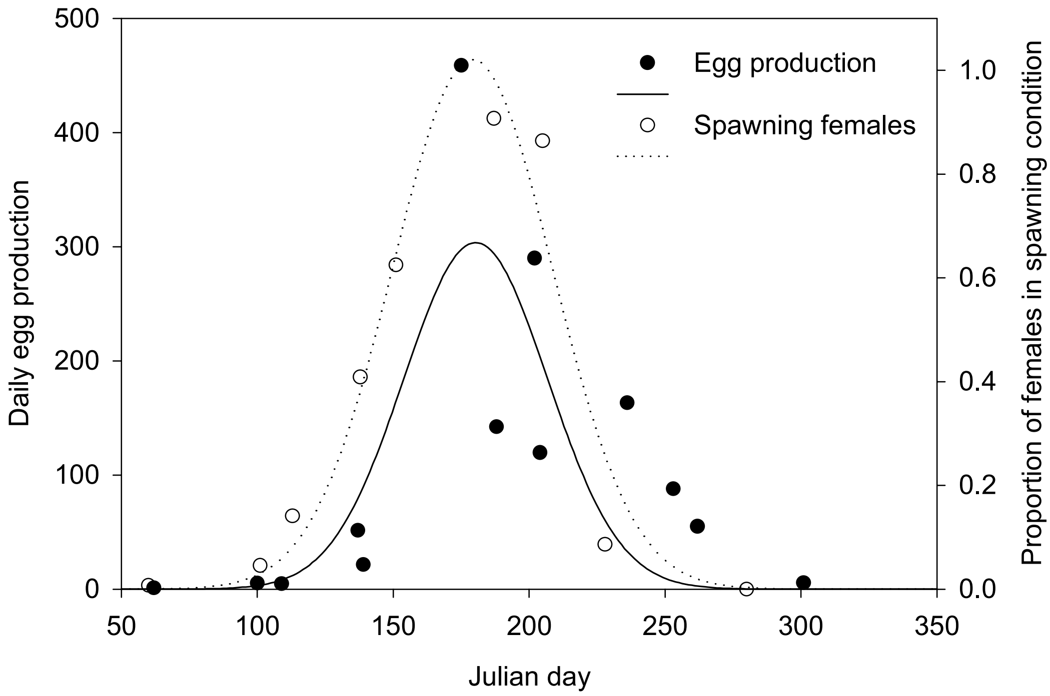


Fig. 1.2.28. Comparison of proportion of cod females in spawning condition (stages V-VII) based on maturity staging and estimates of daily egg production derived from ichthyoplankton surveys in SD 25 for the years 1995, 1996, 1998 and 1999 combined.

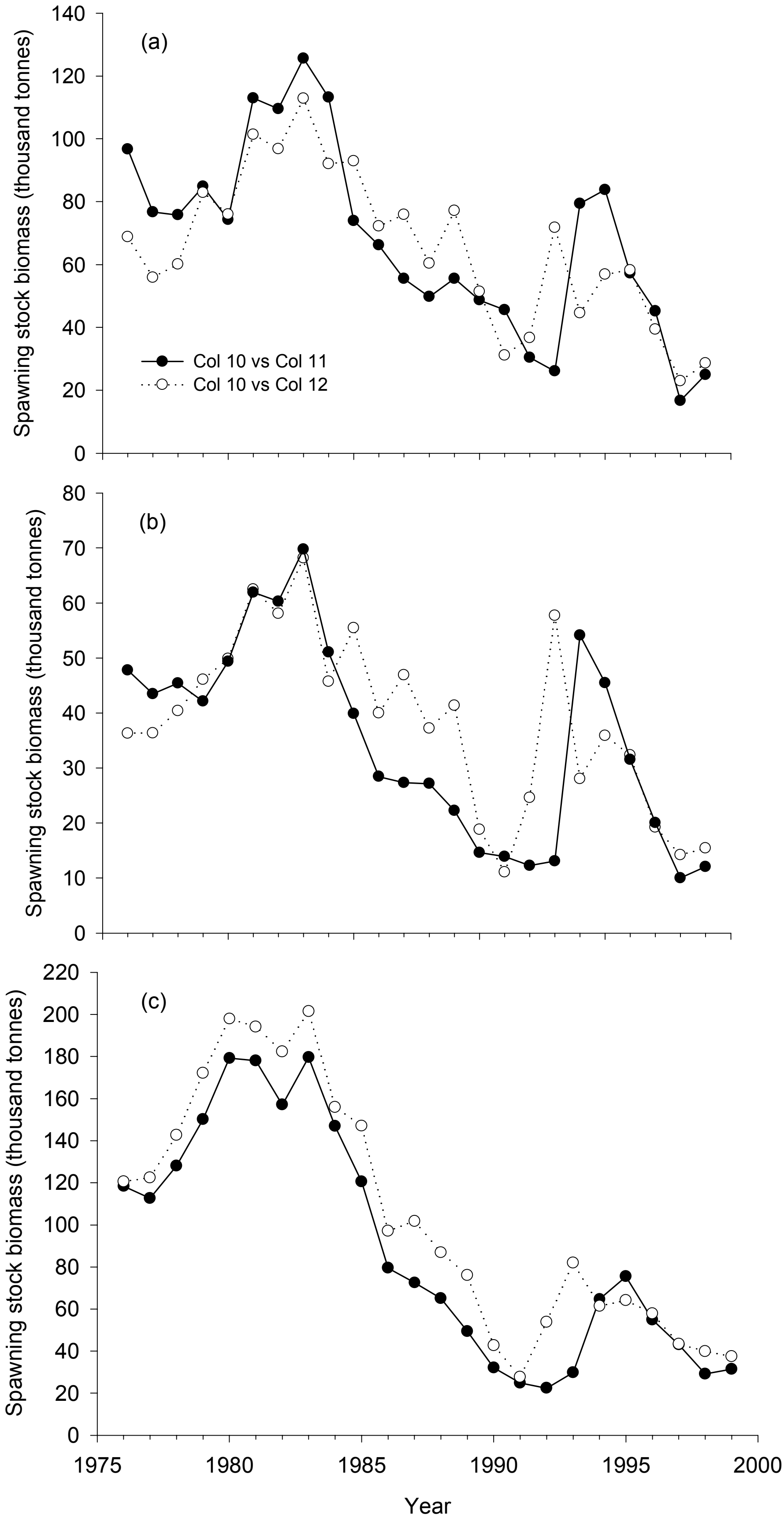


Fig. 1.2.29. Cod male and female spawning stock biomass in Sub-division 25 (1st quarter) (a); Sub-division 25 at peak spawning time (b); and Sub-division 25, 26 and 28 at peak spawning time (c).

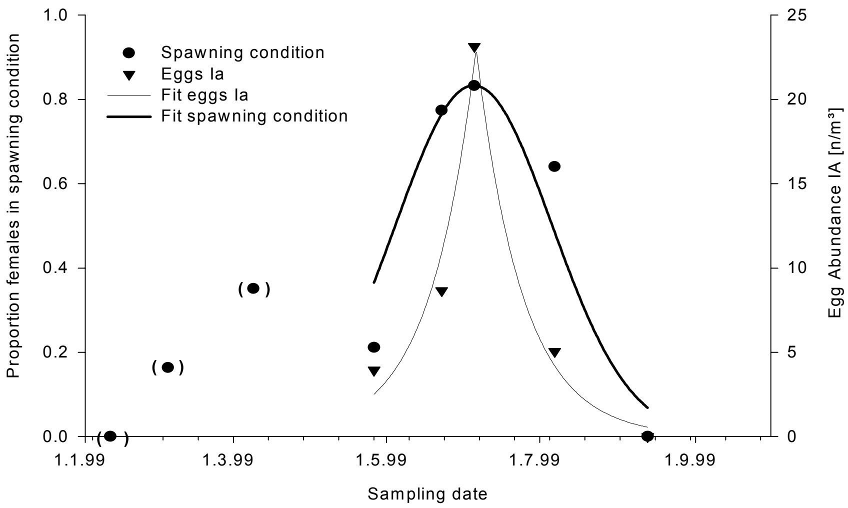


Fig. 1.2.30. Average proportions of mature sprat females in spawning condition and corresponding egg abundance of the youngest egg stage per sampling date. Three respectively four parameter Gaussian curve fit, data in brackets not included.

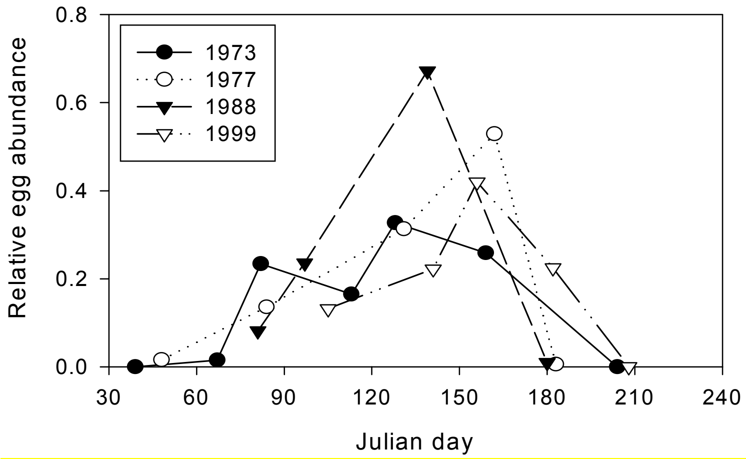


Fig. 1.2.31. Seasonal development of relative sprat egg abundance (stage I) in the Bornholm Basin.

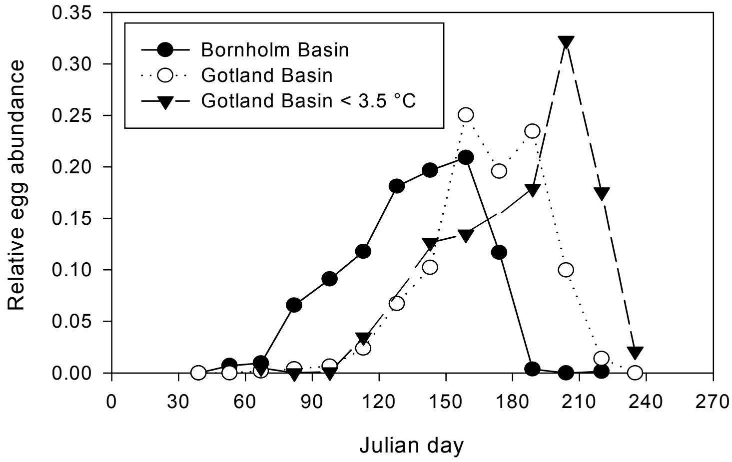


Fig. 1.2.32. Seasonal development of the average relative sprat egg abundance (stage I) in the Bornholm and Gotland Basin (1973-1989) under normal temperature conditions and in the Gotland Basin in cold winter years (temperature in the intermediate water in May at 40-80 m depth: < 3.5 °C).

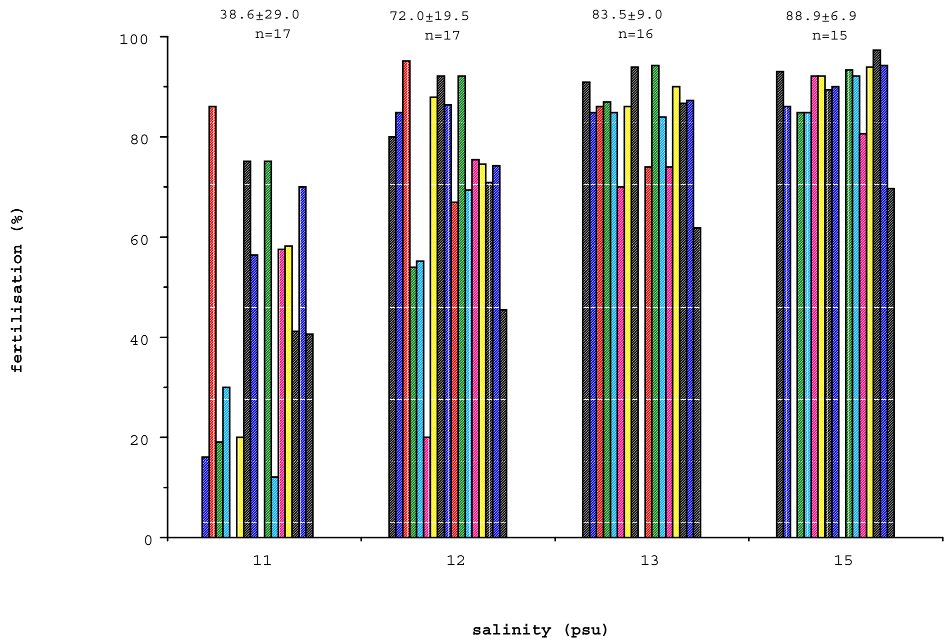
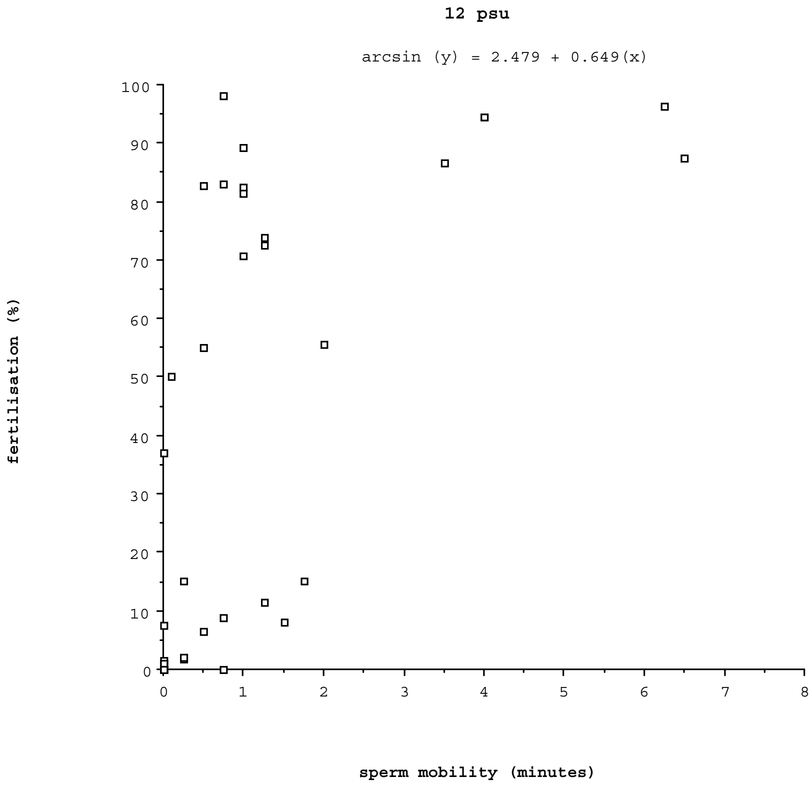


Fig. 1.3.1. Percentage (average ± sd) of fertilised cod eggs at different salinities using 17 different males.

a)



b)

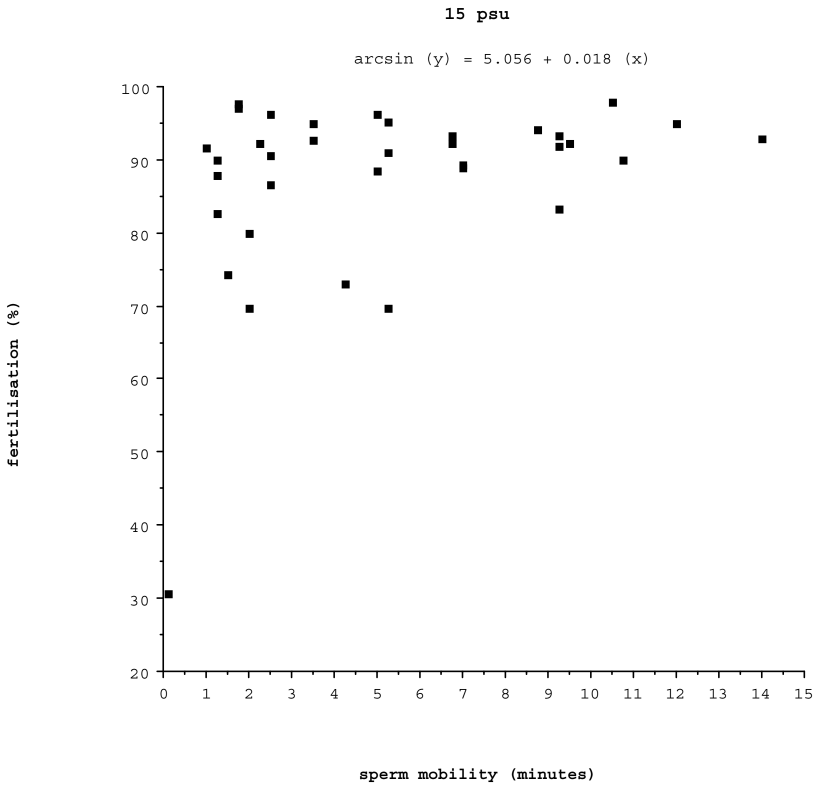
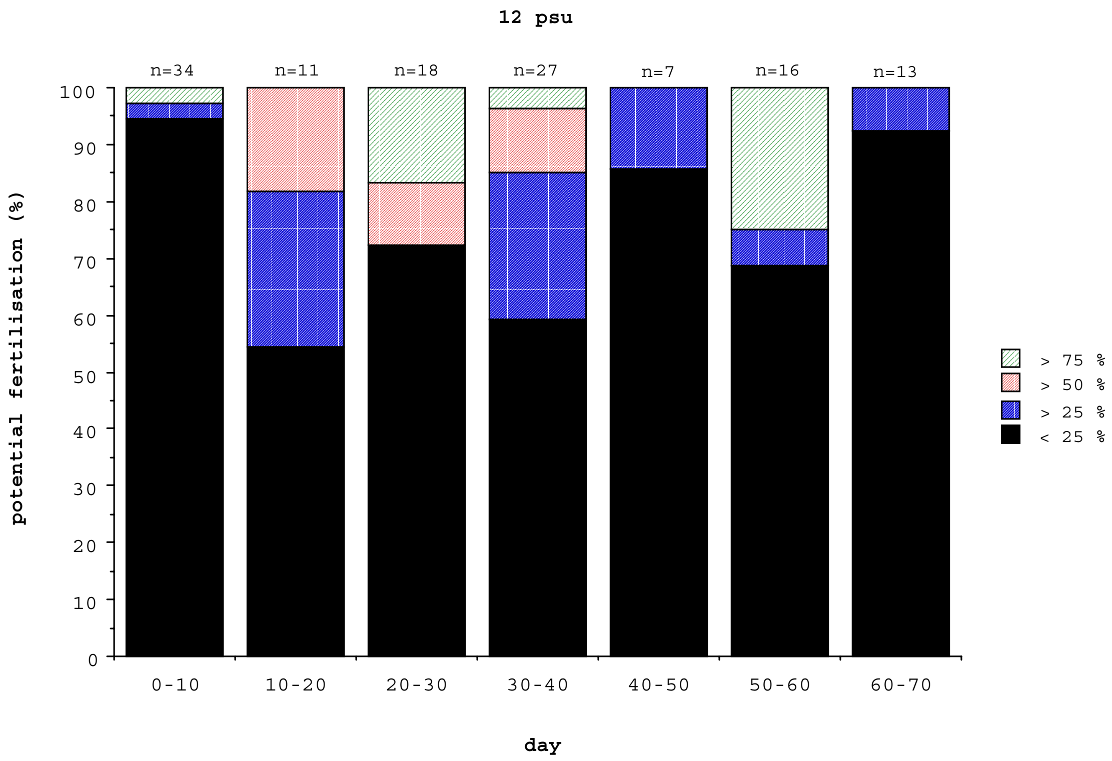


Fig. 1.3.2. Relationship between duration of cod spermatozoa mobility and fertilisation at a) 12psu (n=36) and b) 15 psu (n=35).

a)



b)

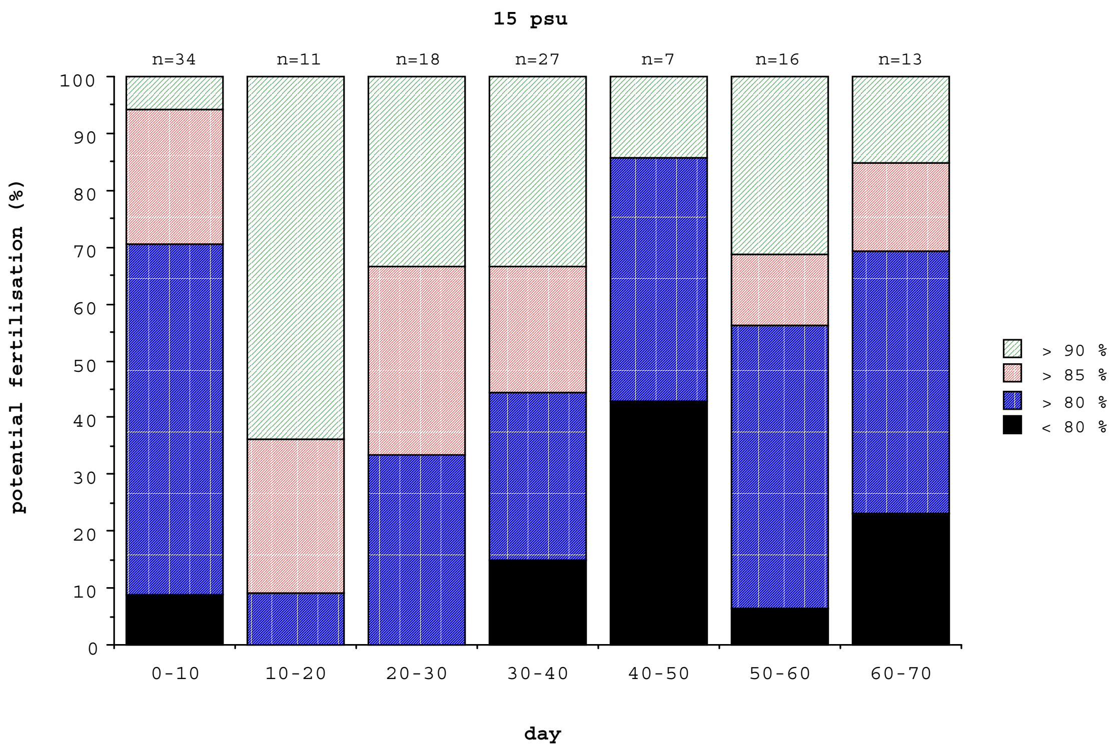
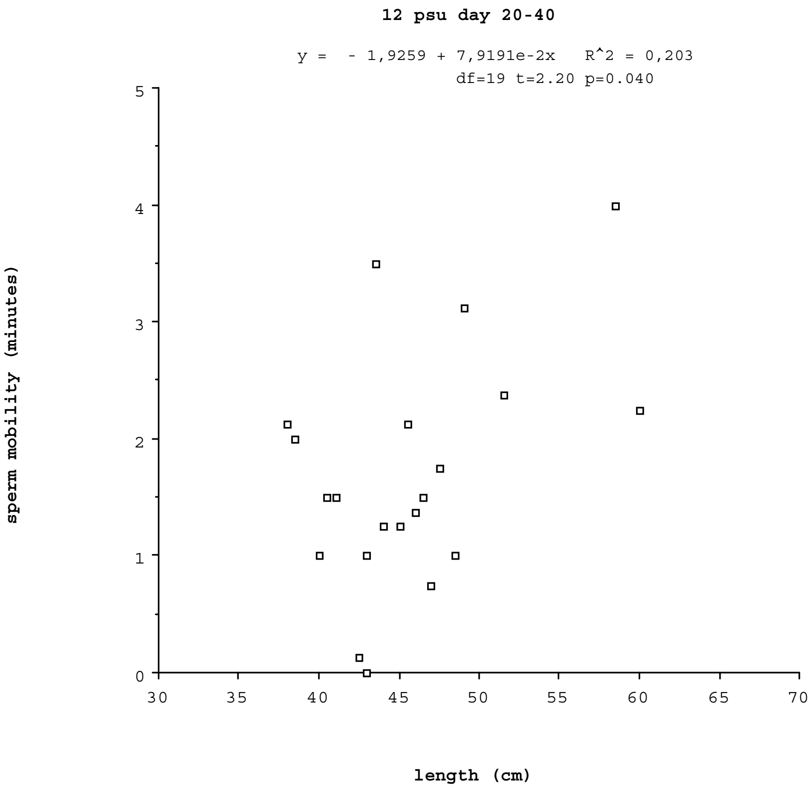


Fig. 1.3.3. The share of males with a fertilisation capacity corresponding to a certain fertilisation level at a) 12 psu and b) 15 psu during the spawning period; calculated from relationship between duration of spermatozoa mobility and fertilisation, and measurements of spermatozoa mobility at respective salinity during the spawning period of individual males.

a)



b)

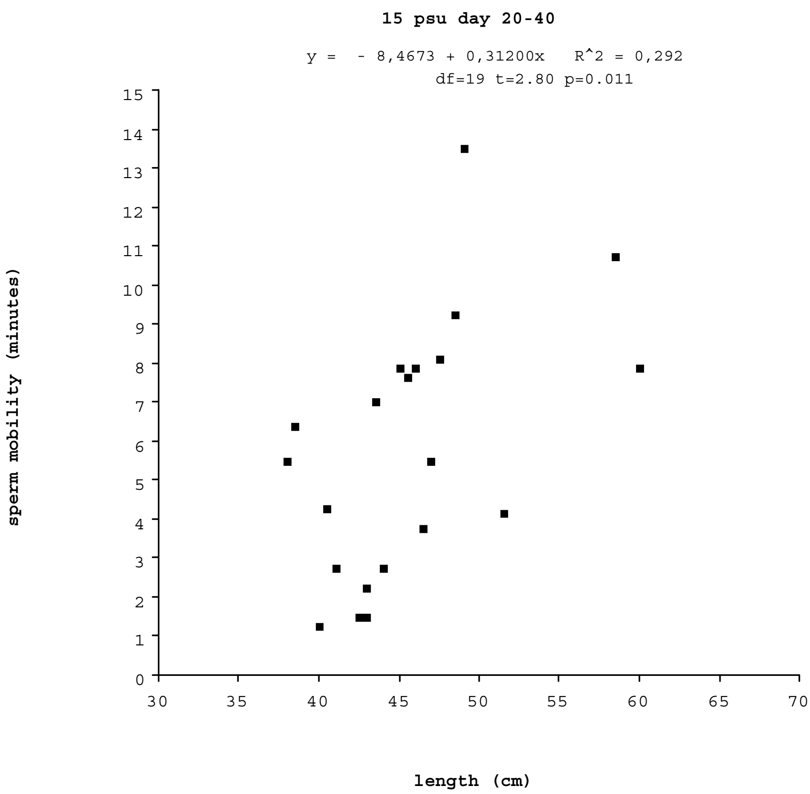
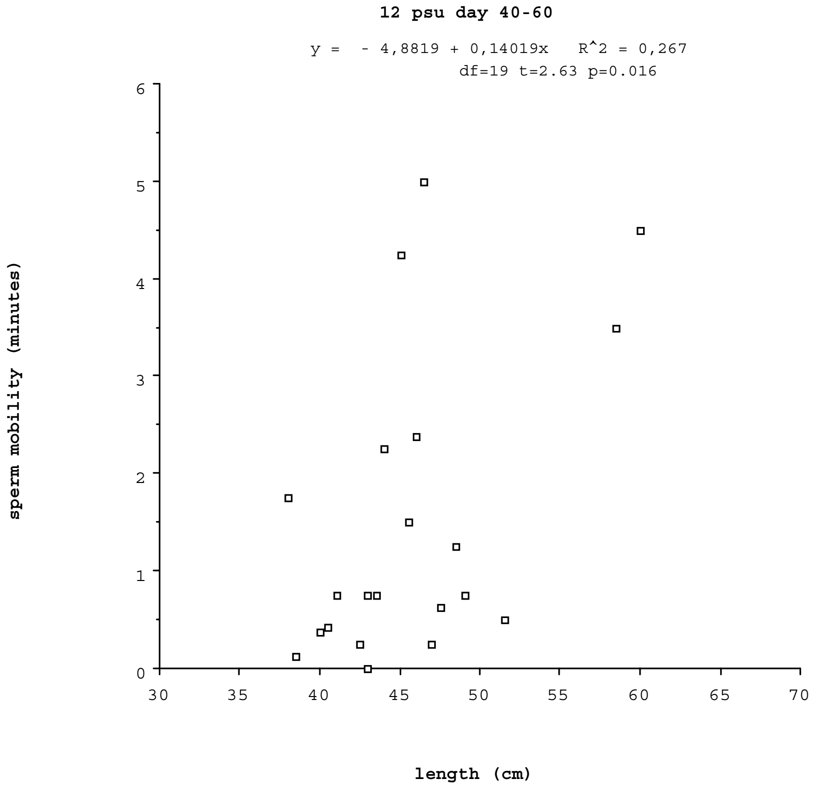


Fig. 1.3.4. The relationship between male length and duration of spermatozoa mobility at 12 (a) and 15 psu (b) during peak spawning (day 20-40) of individual males.

c)



d)

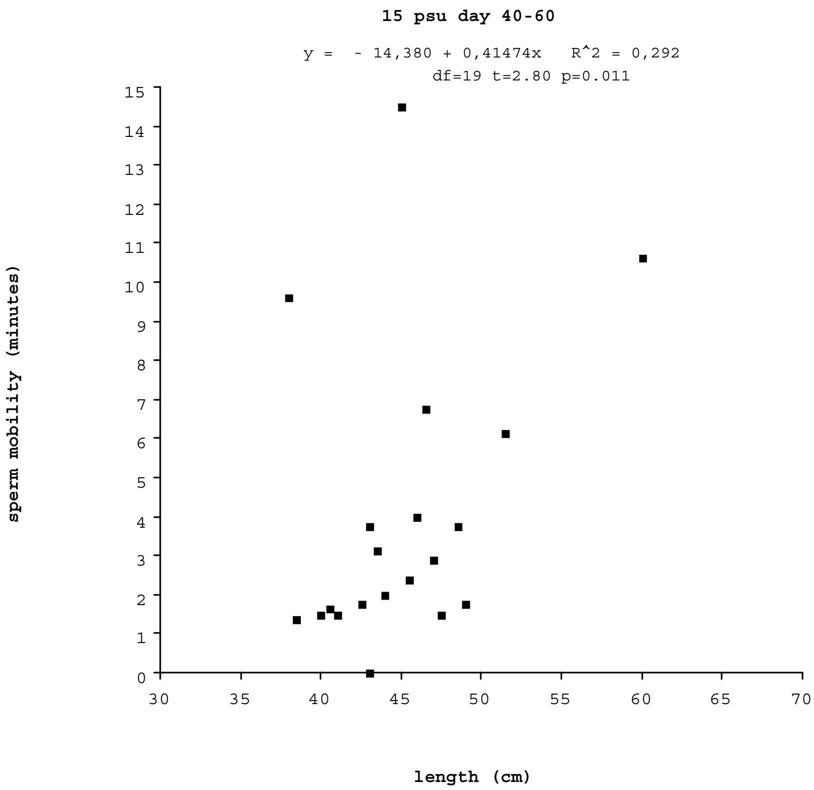
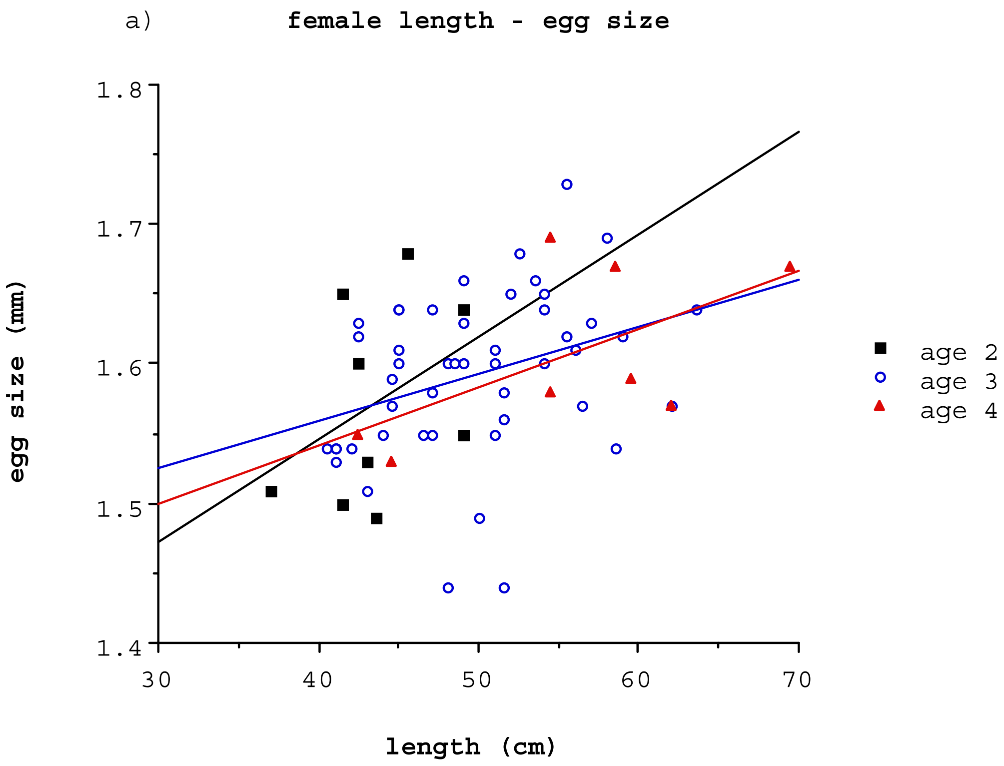


Fig. 1.3.4 (contnued). The relationship between male length and duration of spermatozoa mobility at 12 (c) and 15 psu (d) during late spawning (day 40-60) of individual males.



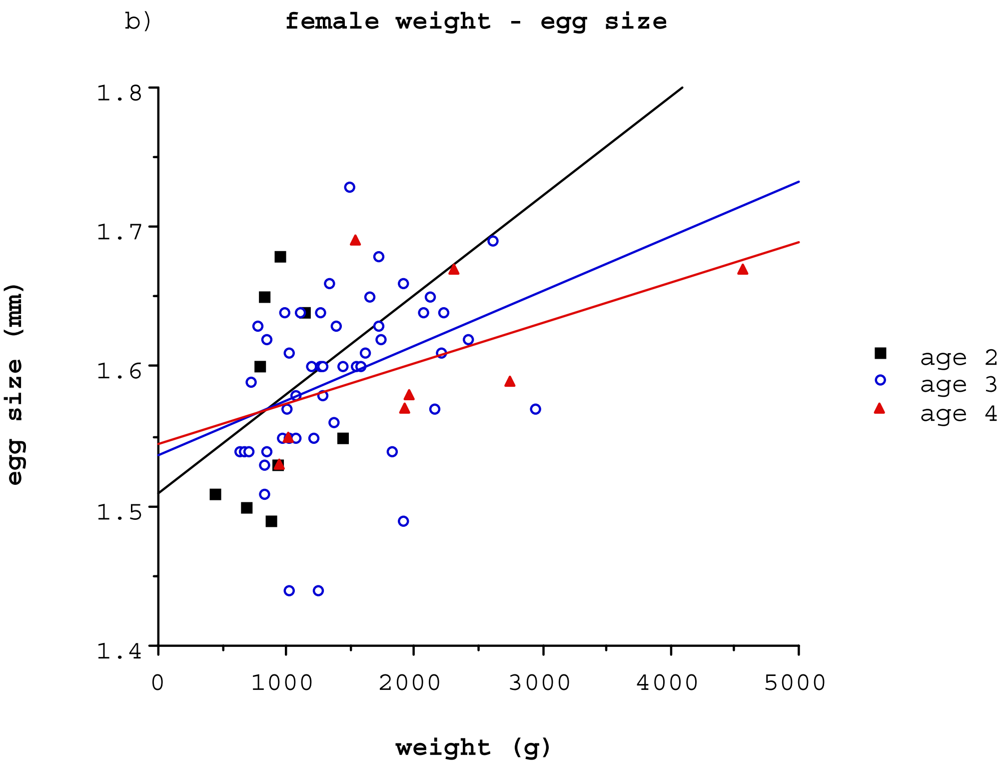


Fig. 1.3.5. Relationship between egg diameter of Baltic cod and female size; a) in length b) in weight at start of spawning.

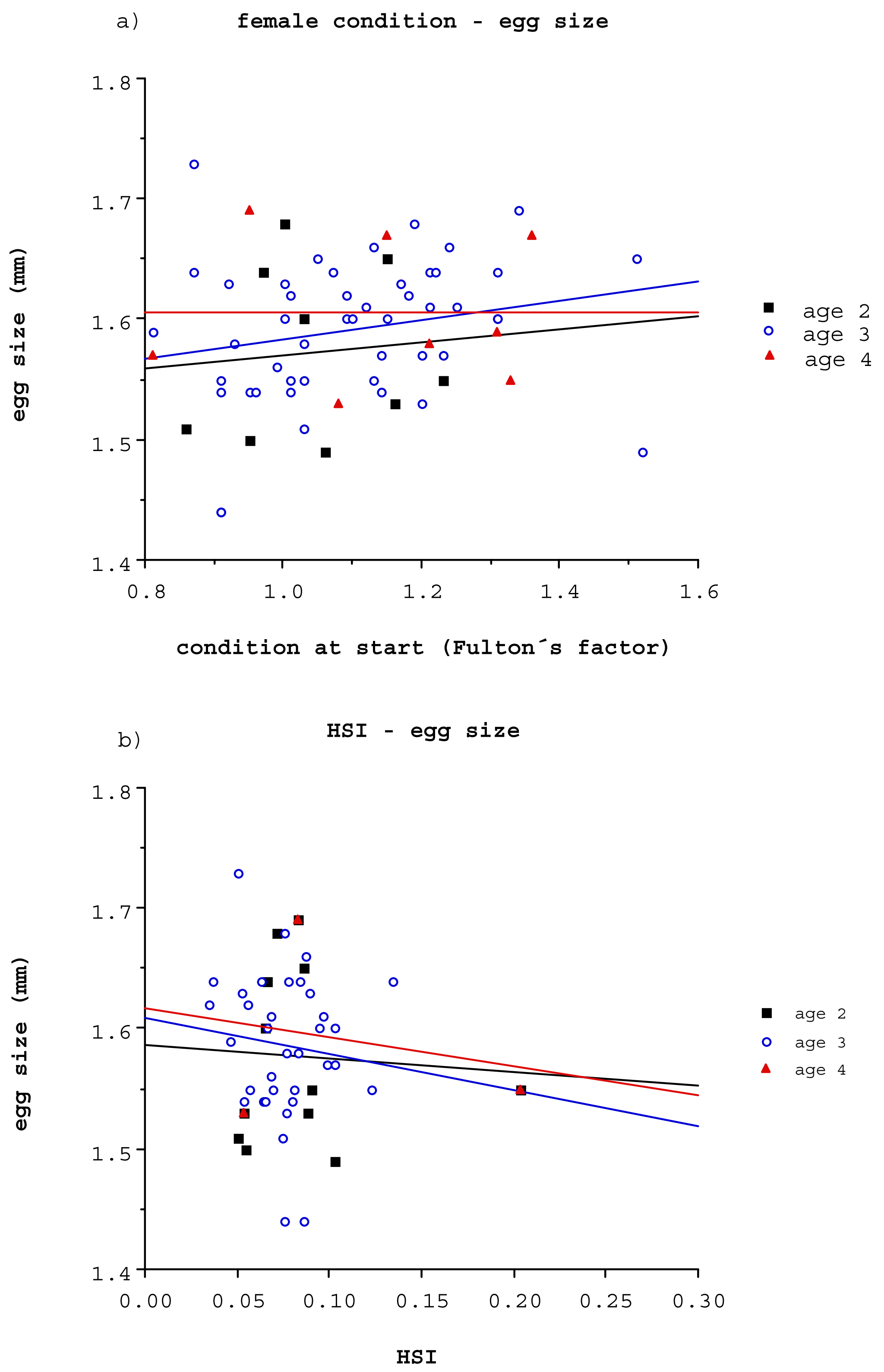


Fig. 1.3.6. Relationship between egg diameter of Baltic cod and female condition; a) as Fulton´s condition factor b) as Hepatosomatic index at start of spawning.

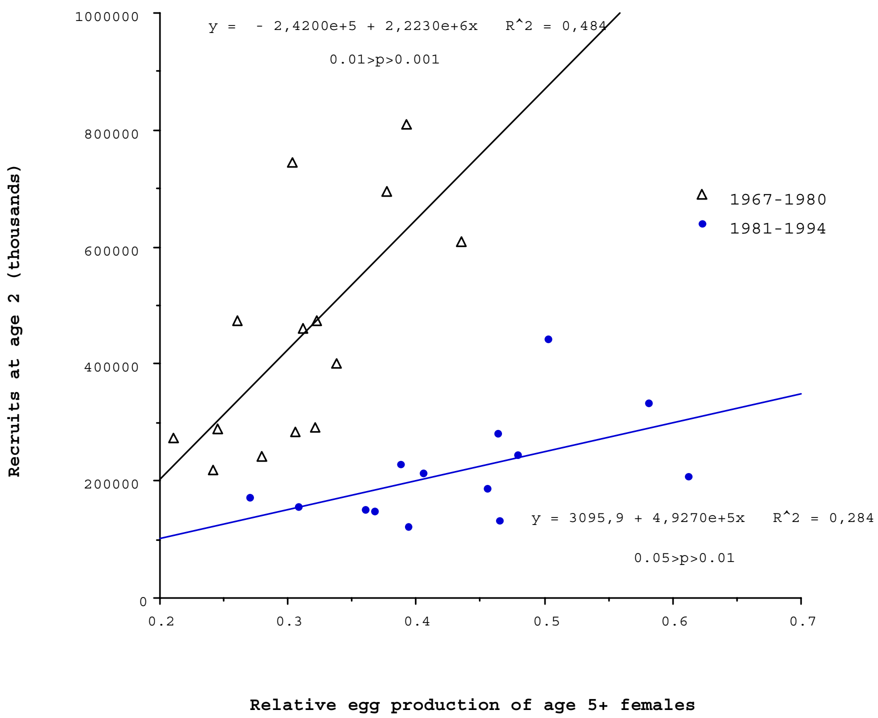


Figure 1.3.7. Relationship between recruitment at age 2 and relative egg production by age 5+females for Baltic cod during the period 1967-1994.

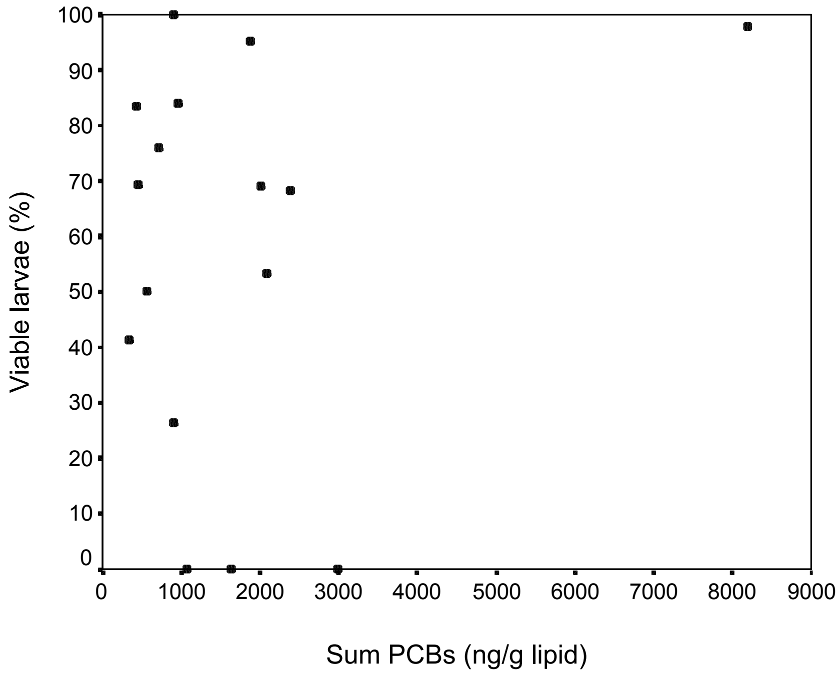


Fig. 1.3.8a. Relation between ovary burden of PCBs (ng/g lipid) and viable larvae (%) from Baltic cod caught in Bornholm Basin in July and August 2000, n = 16.

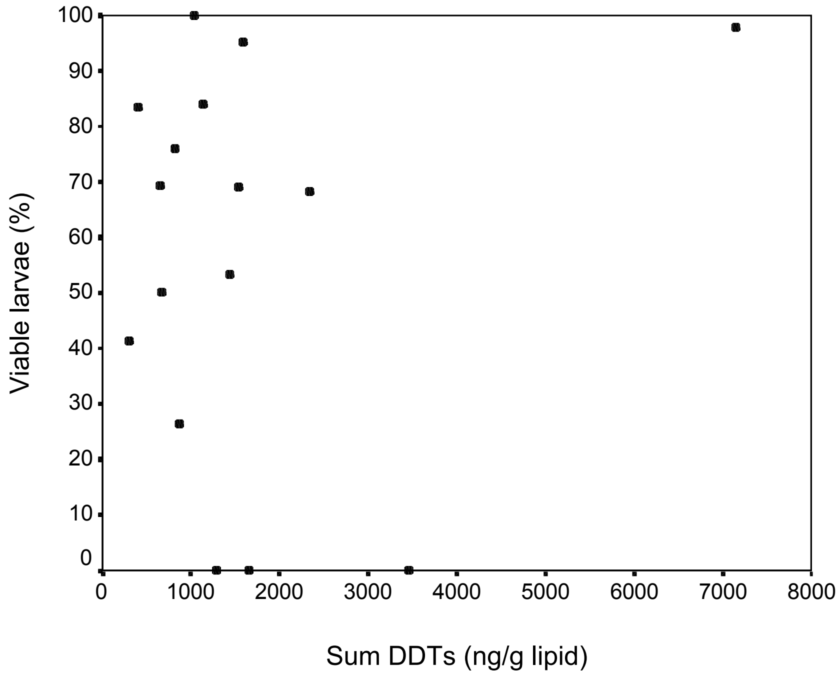
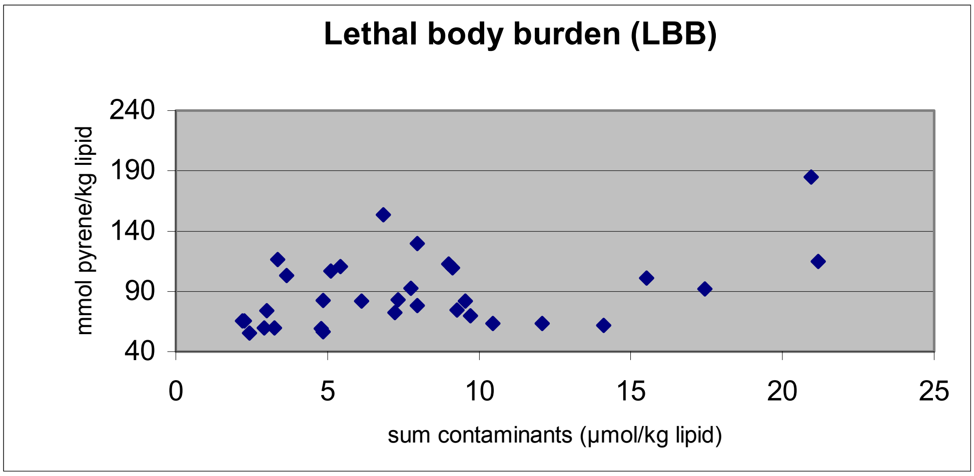
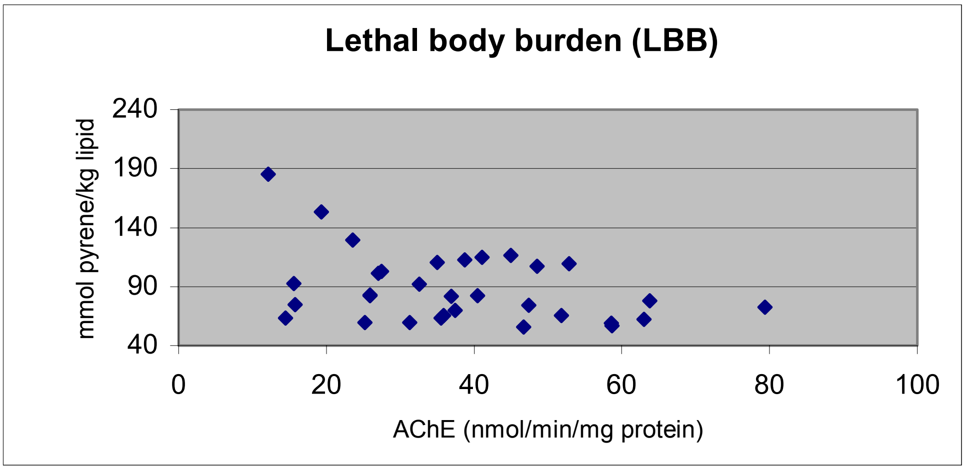


Fig. 1.3.8b. Relation between ovary burden of DDTs (ng/g lipid) and viable larvae (%) from Baltic cod caught in Bornholm Basin in July and August 2000, n=16.





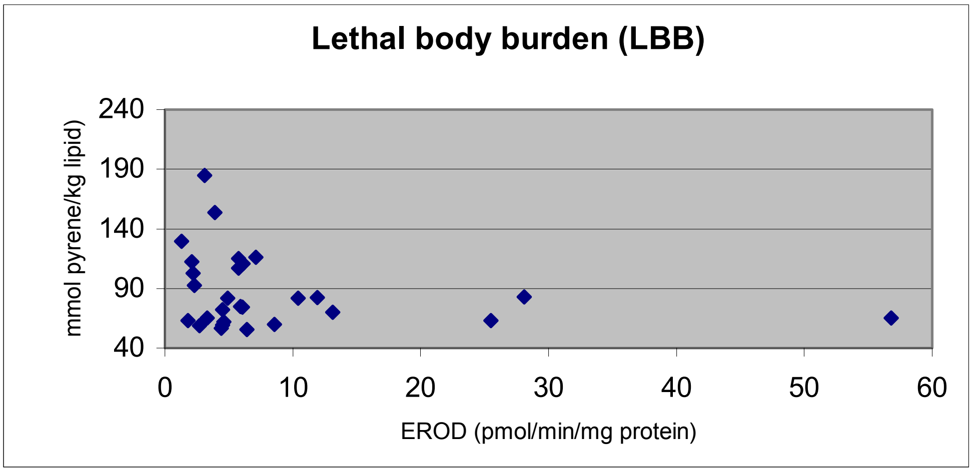


Fig. 1.3.9. Relation between contaminant content or enzyme activity (EROD, AchE), respectively, in female cod (Bornholm Basin, July 1999) and lethal body burdens (LBB) in the larvae.

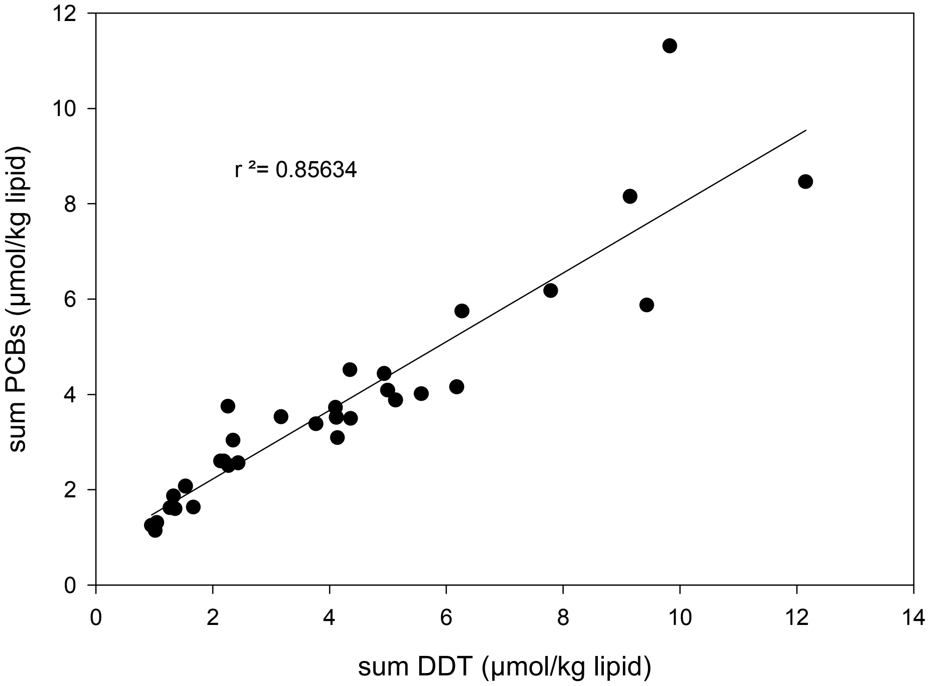


Fig. 1.3.10. Relation between PCB ∑ PCBs (congeners 52, 101, 105, 118, 138, 149, 153 and 180) and DDT (∑ DDT, DDD and DDE) content (µmol/kg lipid) in ovaries of female cod from the Bornholm Basin (n=32).

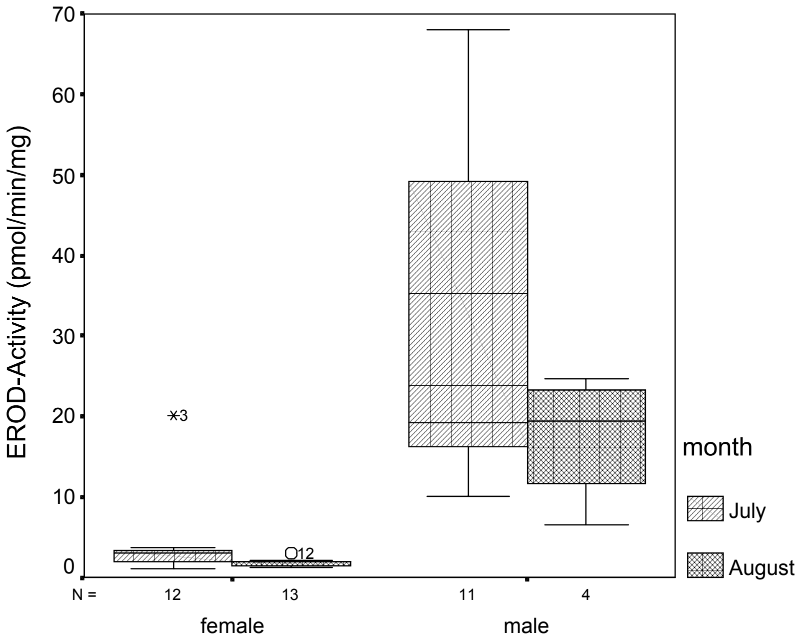


Fig. 1.3.11. Variation of the hepatic EROD-activity (pmol/min/mg microsomal protein) of Baltic cod in July and August 2000. The boxes include 50 % of the cases and the rest 50 % is presented by the upper and lower quartiles (both 25 %). The bigger the box is, the greater variation the values show. Exceptionally high values are shown with * (female 3).

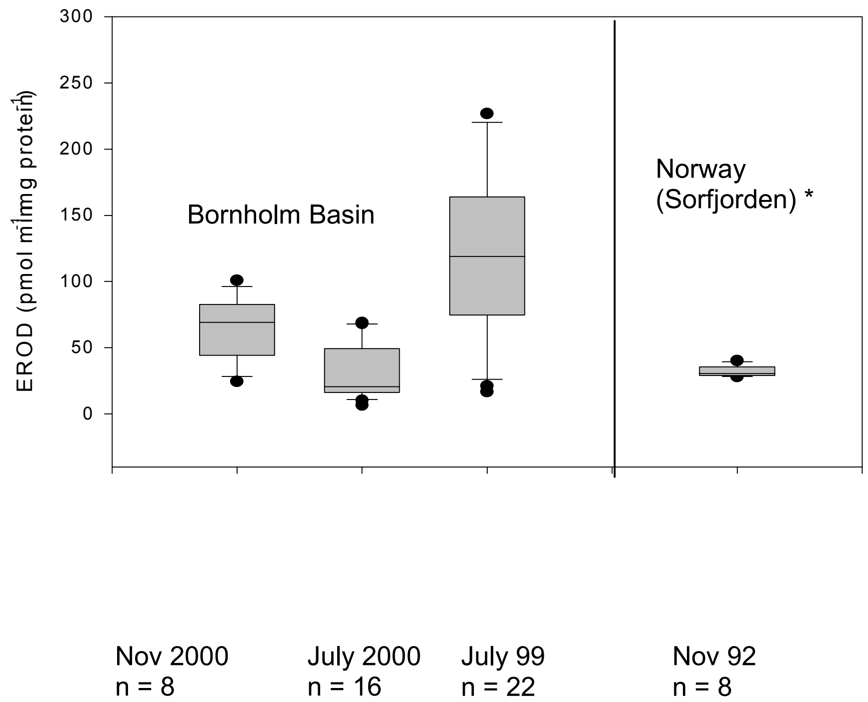


Fig. 1.3.12. EROD-activity (pmol/min/mg protein) in liver tissues of male Baltic cod (Bornholm Basin) in comparison to Atlantic cod (females and males; 6:2) subjected to caging at polluted sediments in a Norwegian fjord (Sørfjorden) for a period of 3 months (Beyer et al. 1996).

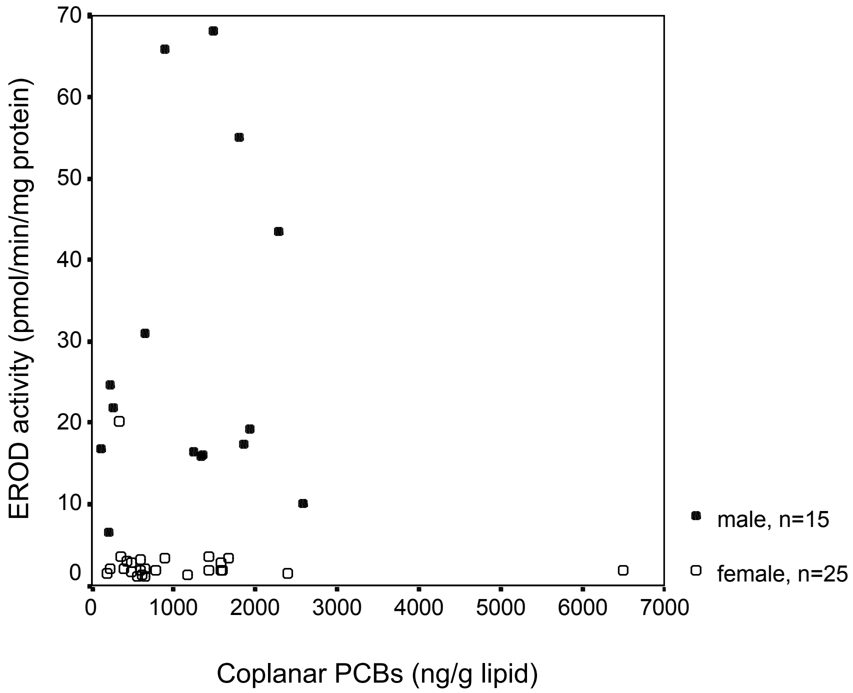


Fig. 1.3.13. Relation between ovary (females) or liver and testis (males) burden of PCBs (here: congeners 153, 138, 118, 105 and 180) and EROD-activity (pmol resorufin/min/mg microsomal protein).

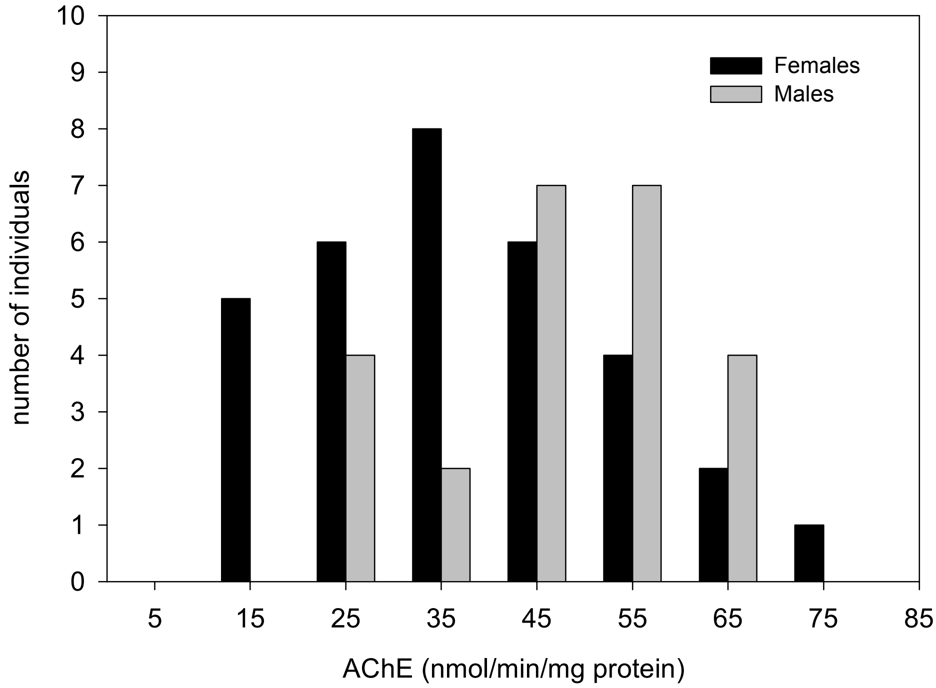


Fig.1.3.14. Frequency distribution of AChE activity (nmol/min/mg protein) in muscle tissue of female (n=32) and male (n=24) cod from Bornholm Basin (July 1999).

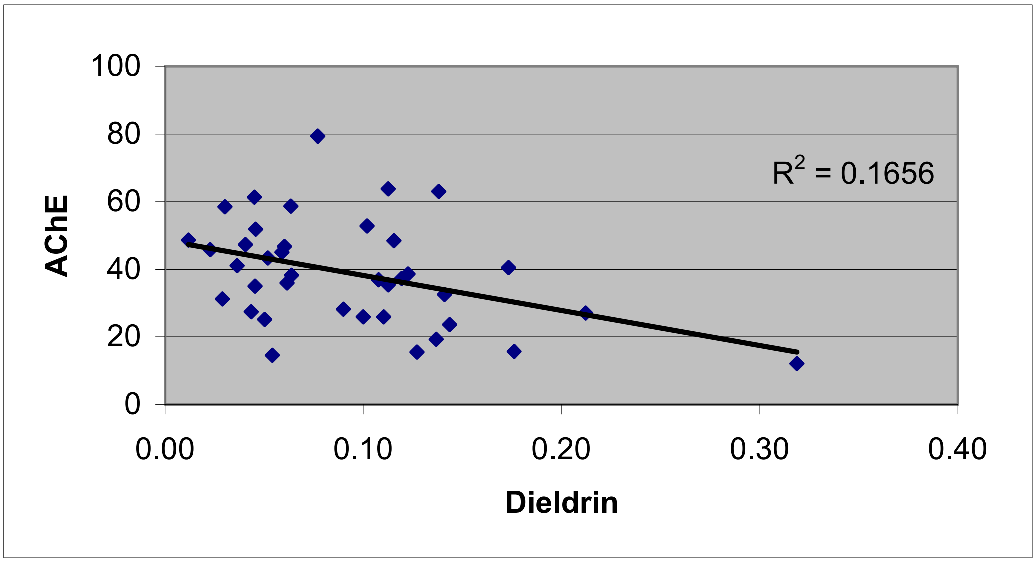
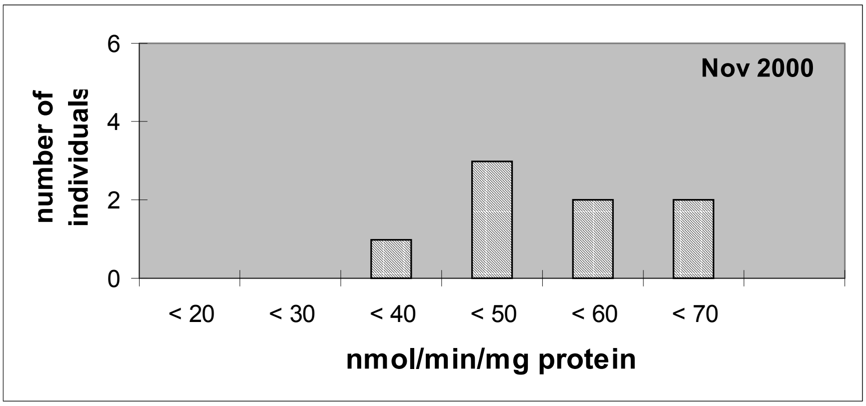
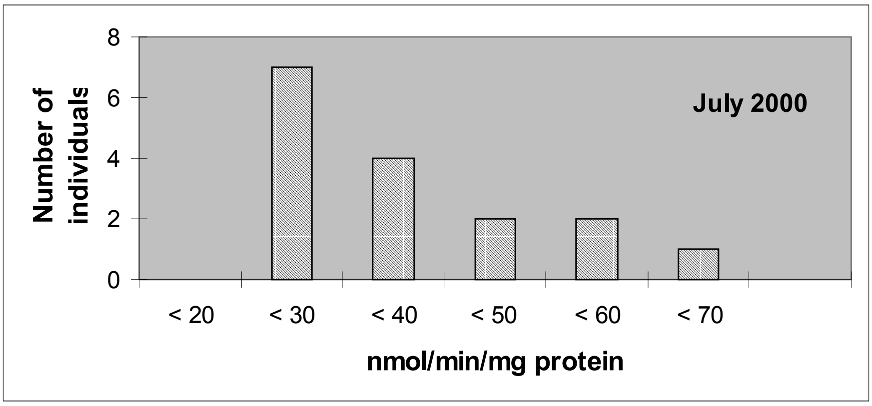


Fig. 1.3.15. Activity of AChE (nmol/min/mg protein) in muscle tissue versus dieldrin content (µmol/kg lipid) in the ovaries of running-ripe female cod (n=38) from Bornholm Basin (July 1999, July/August 2000).





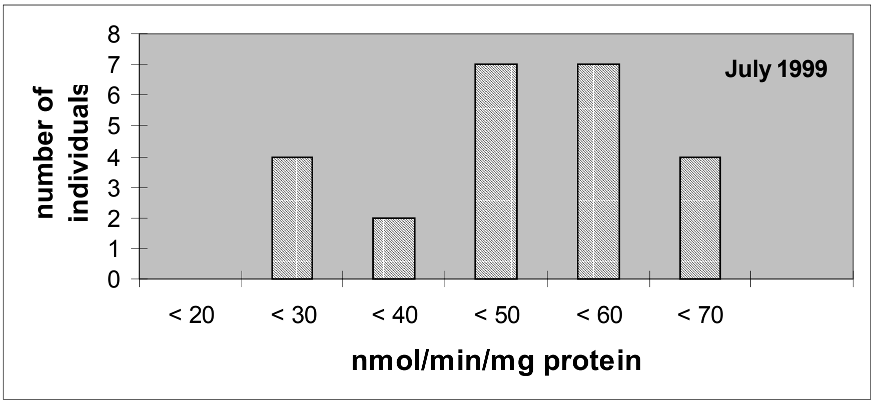


Fig. 1.3.16. AChE activity in muscle tissue of male Baltic cod from the Bornhom Basin in July 1999 and 2000 and November 2000.

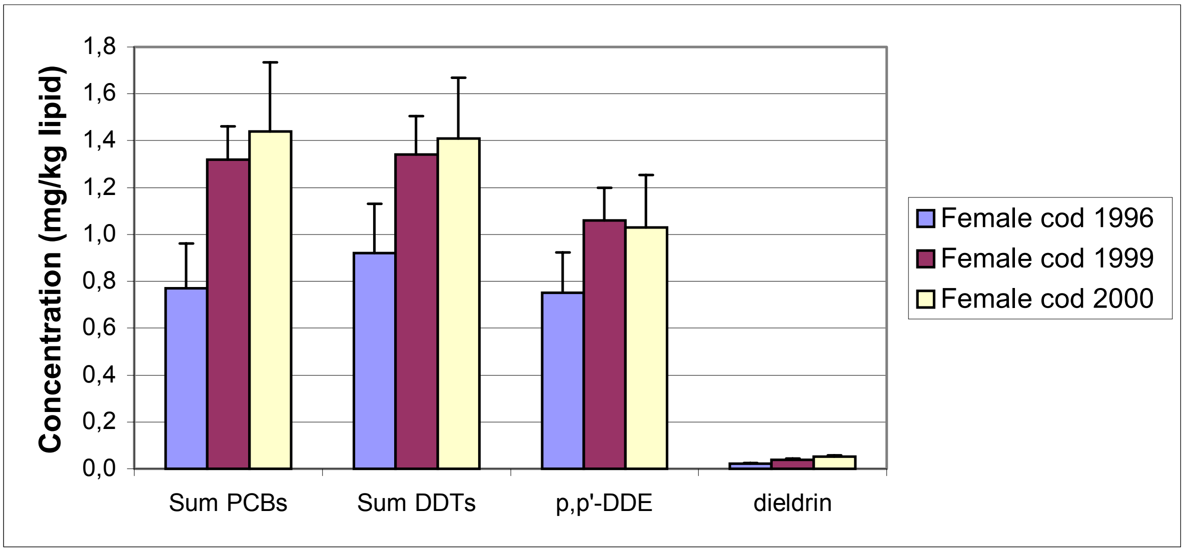


Fig. 1.3.17. Organo-chlorine concentrations in mg/kg lipid (mean + S.E.) measured in ovaries of Baltic cod caught in the Bornholm Basin in 1996 (CORE project), 1999 and 2000 (STORE project).

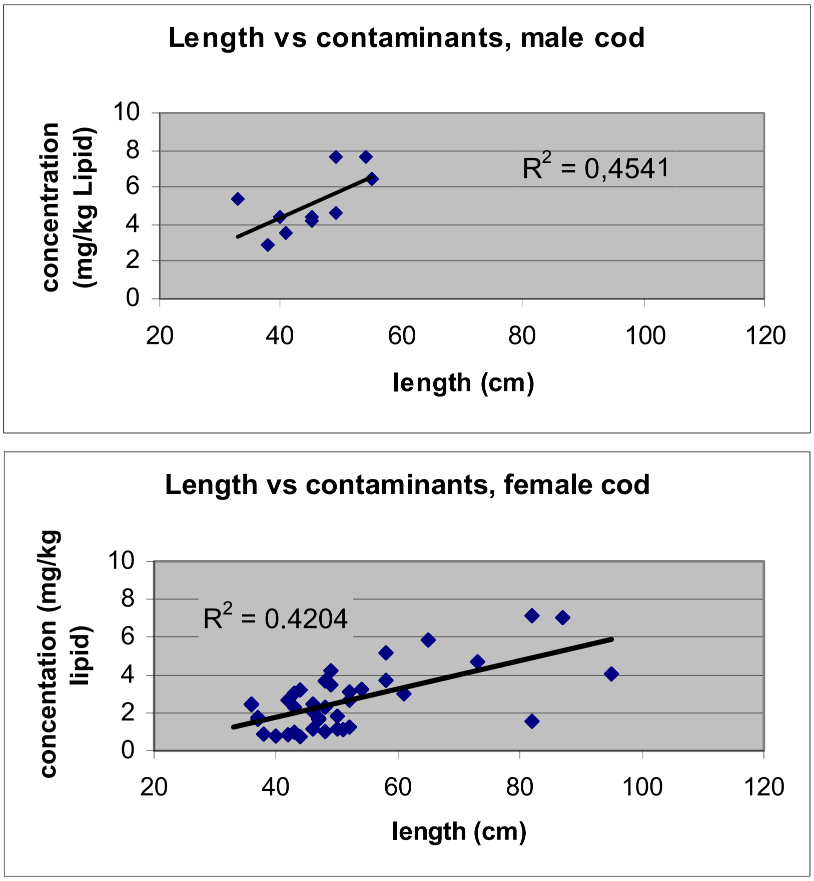
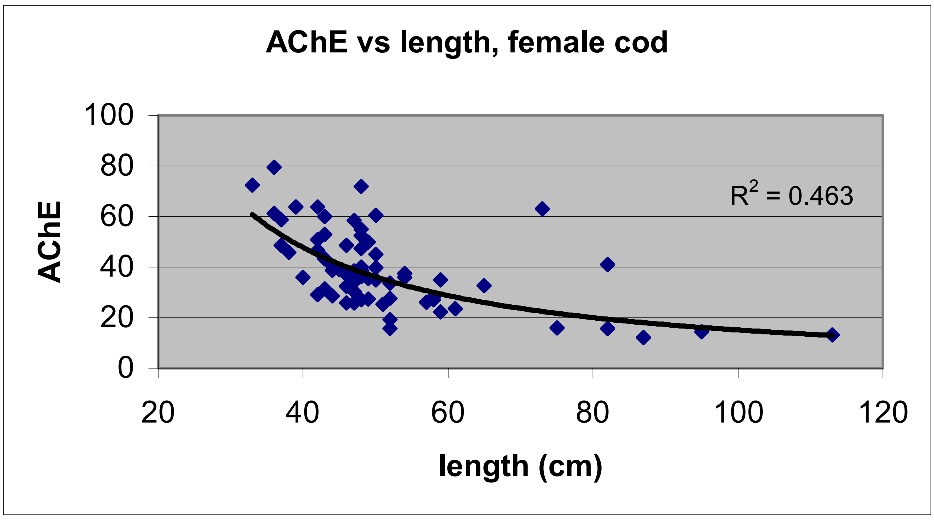


Fig. 1.3.18. Relation between length and contaminant level in female (n=39) and male (n=11) cod from Bornholm Basin in summer 1999 and 2000.



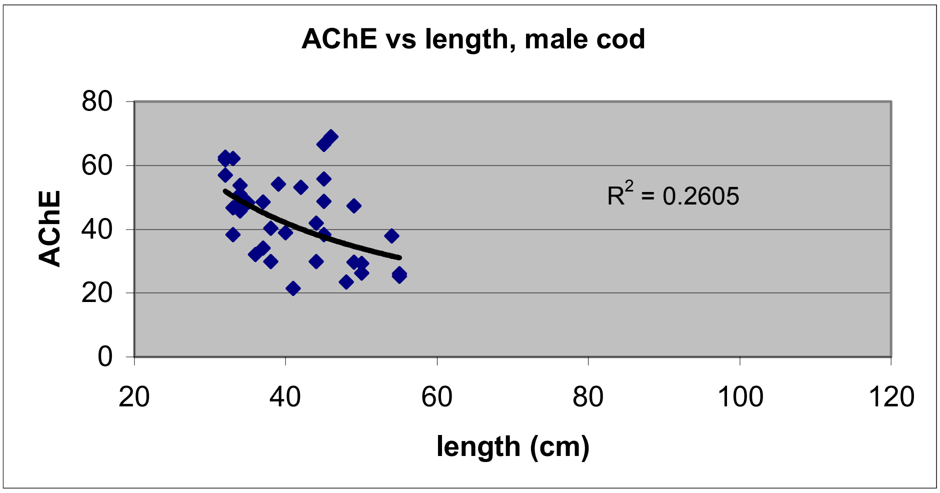


Fig. 1.3.19. Relation between length and contaminant level in female (n=39) and male (n=11) cod from Bornholm Basin in summer 1999 and 2000.

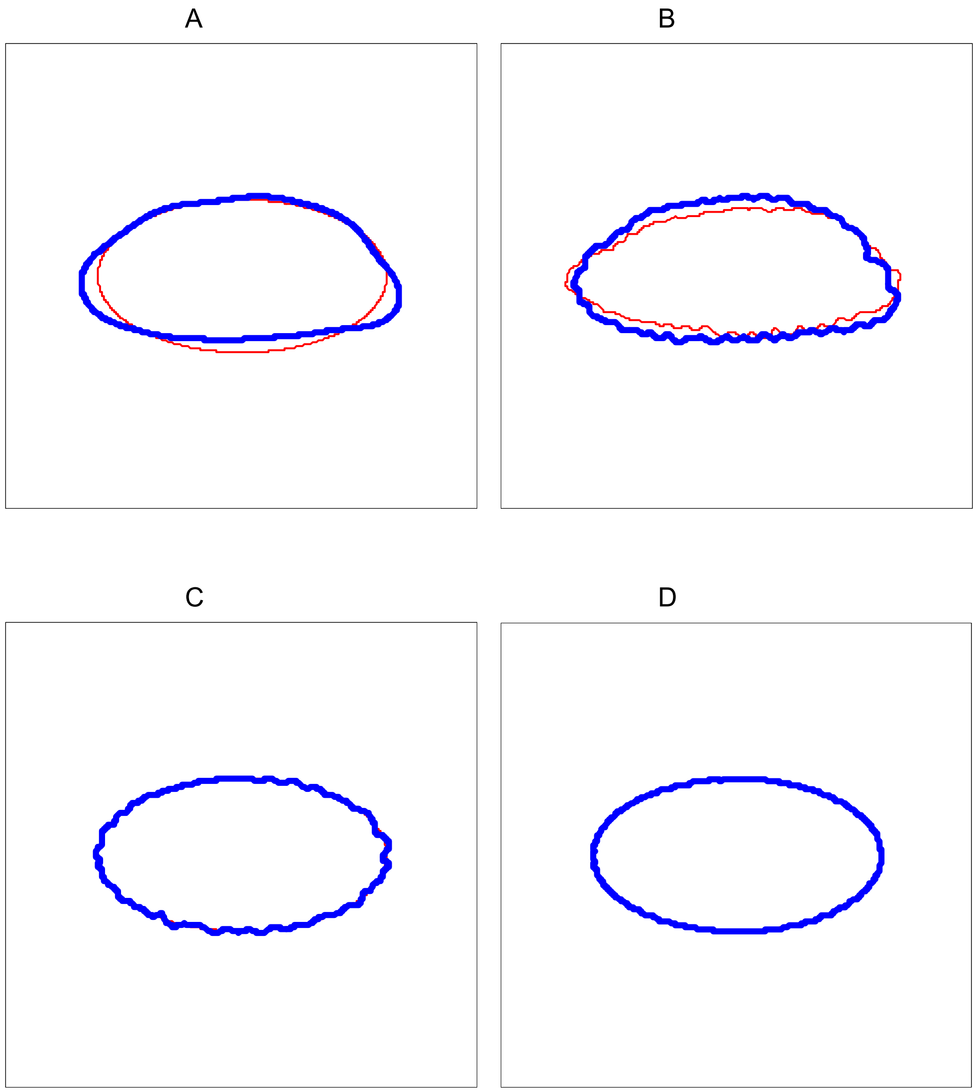


Fig. 1.4.1. Cod sagitta otolith contour reconstructed with i complex Fourier descriptors (FD).
A) Left upper panel: for demonstration the otolith from the cod with the lowest relative fecundity (RF=126 eggs/g) thick contour line vs. the cod with the highest RF (1953 eggs/g) thin line are exhibited.
B) Right upper panel: cod otolith contrasting FD i=1 (thin) versus i=1-10 (thick);
C) Left lower panel: cod otolith contrasting FD i=1 versus i=11-43.
D) Right lower panel: cod otolith contrasting FD i=1 versus i=44-60;

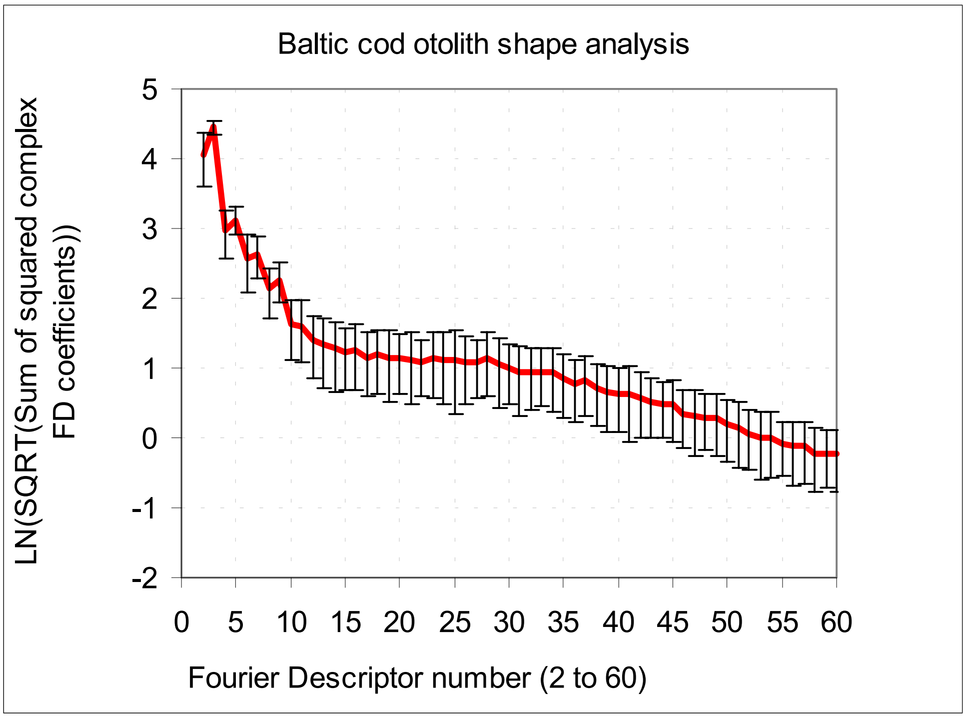


Fig. 1.4.2. Average values of Ln(X_i) +/- stdev. (n=143), versus the descriptor number i, where X_i is the square root of the sum of squared complex components of the ith Fourier Descriptor.

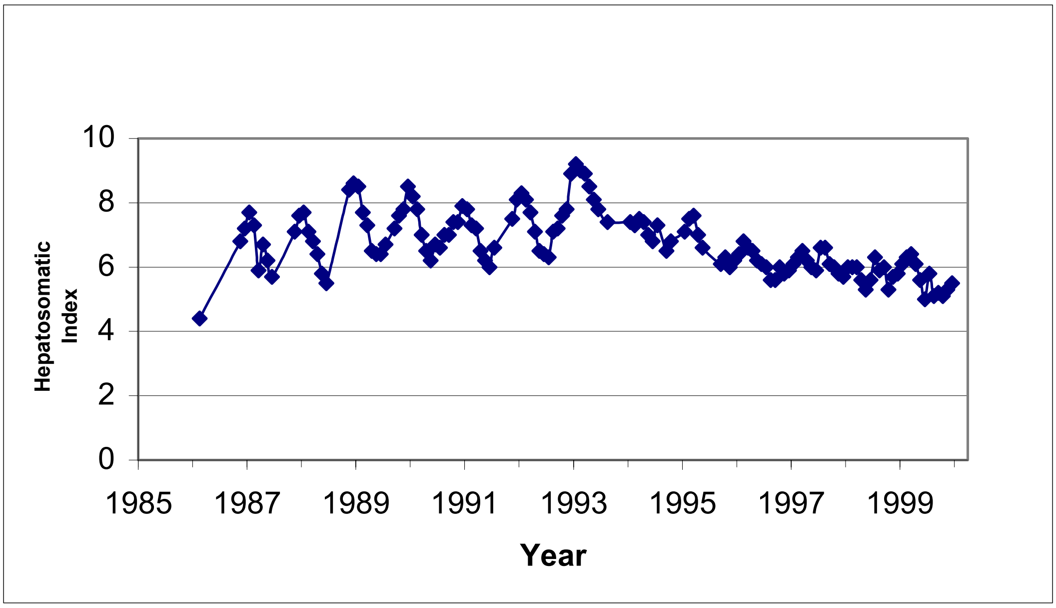


Fig. 1.4.3. Hepatosomatic indices for cod in ICES Division 3D based on Danish commercial cod landings. Indices are derived from group weights (see text for details).

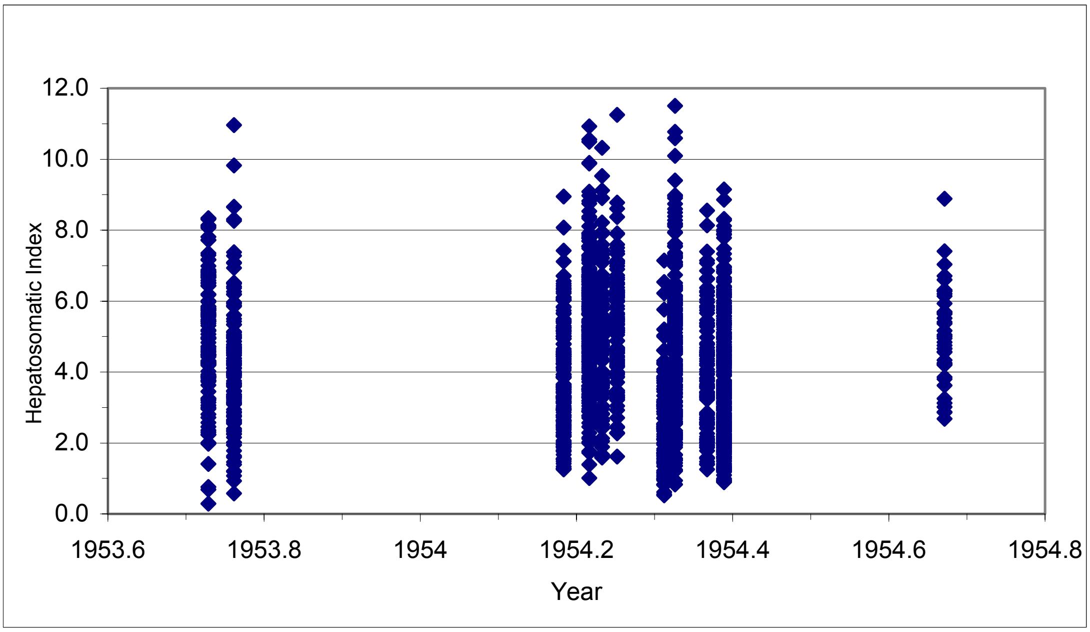
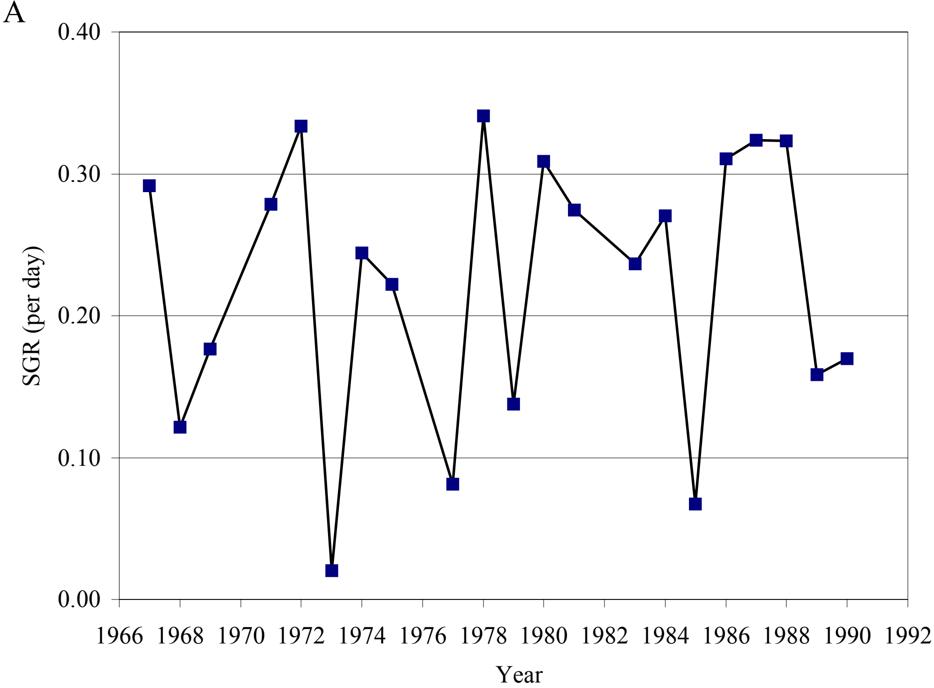


Fig. 1.4.4. Hepatosomatic indices for Baltic cod in ICES Sub-divisions 25 and 26. Data collected by partner 6 as part of German research surveys. Indices are based on paired liver and gutted weight measurements for individual fish.

A



B

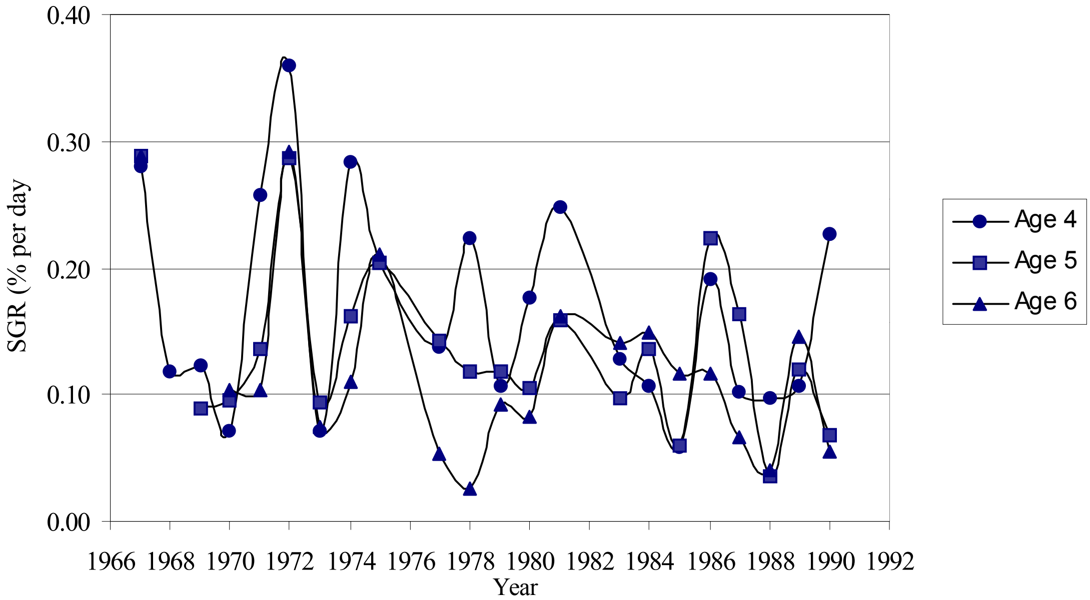


Fig. 1.4.5. Changes in the specific growth rate (SGR, % pery day) of cod. (A) 3-year-old cod. (B) 4-5-6-year-old cod. See details in Uzars et al. (2000).

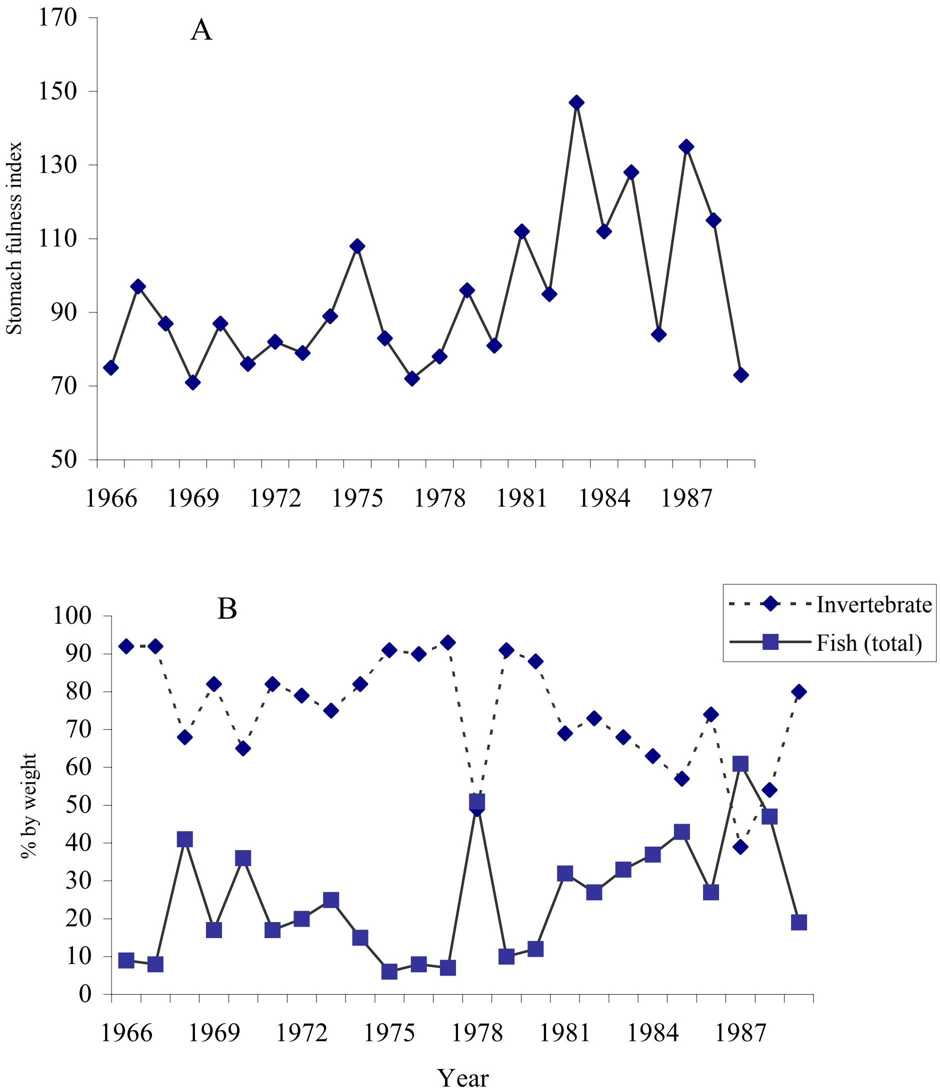


Fig. 1.4.6. Stomach fullness (A) and diet composition (B) of cod in length 30-40 cm in December-January. See details in Uzars et al. (2000).

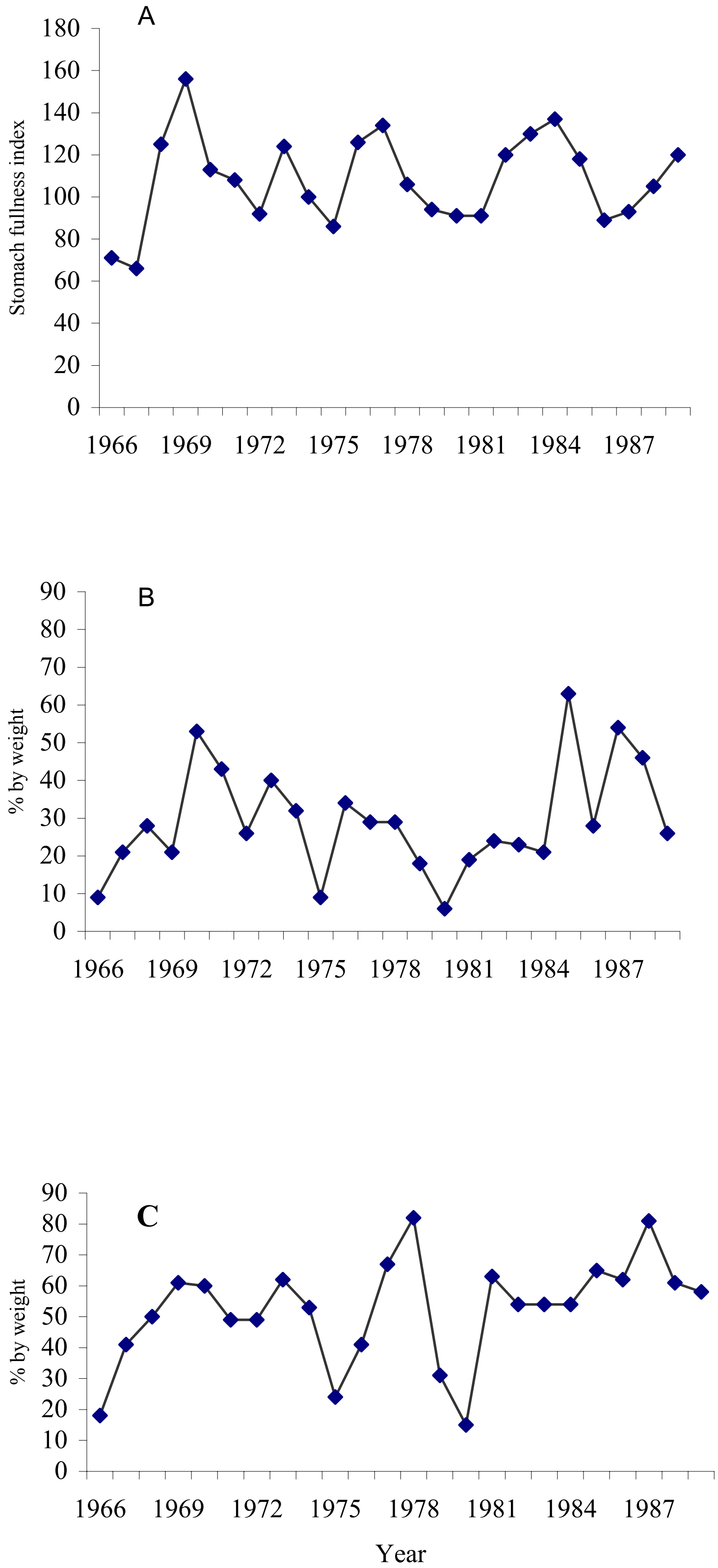


Fig. 1.4.7. Stomach fullness (A) and diet composition (B, C) of cod length >40 cm in December-January. See details in Uzars et al. (2000).

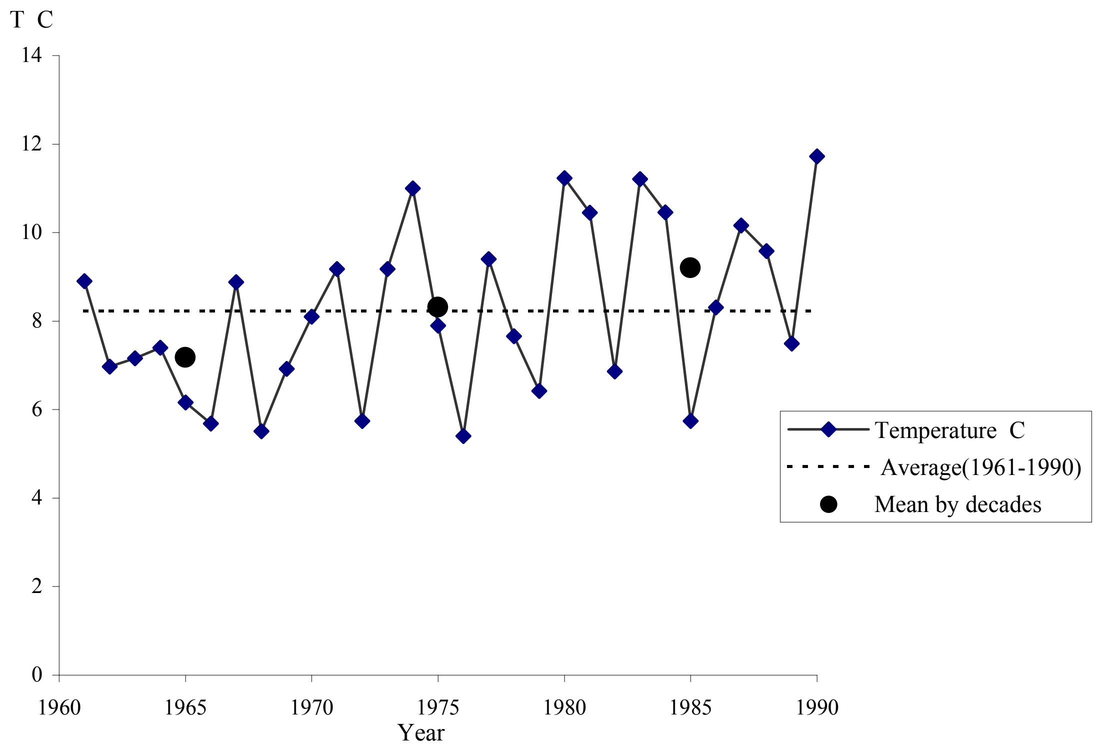


Fig. 1.4.8. Time-series of temperature during autumn (October) in 40-70 m, decadal means and overall mean in the Central Baltic. See details in Uzars et al. (2000).

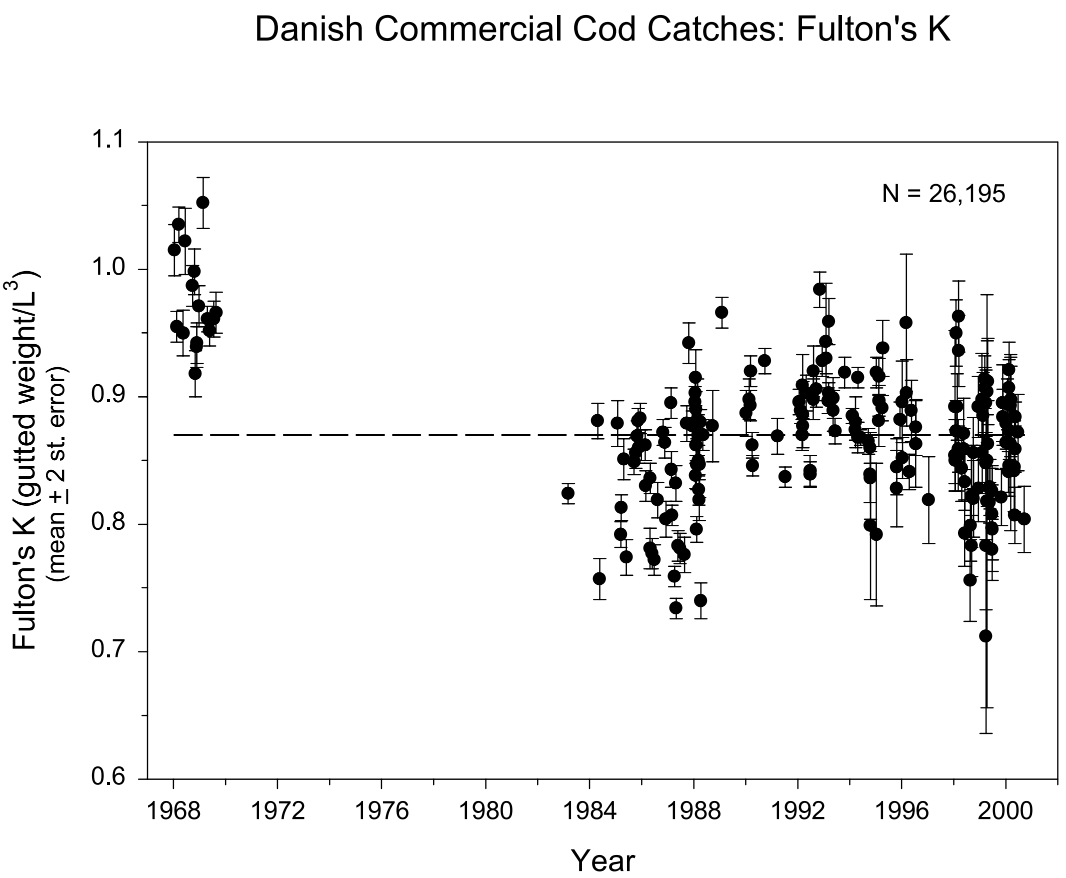


Fig. 1.4.9. Estimates of cod condition (100 x gutted weight/Length^3) based on paired length and weight measurements on individual fish captured by the Danish commercial fishery. All measurements were made on cod captured in ICES subdivisions 25, 26 and 28.

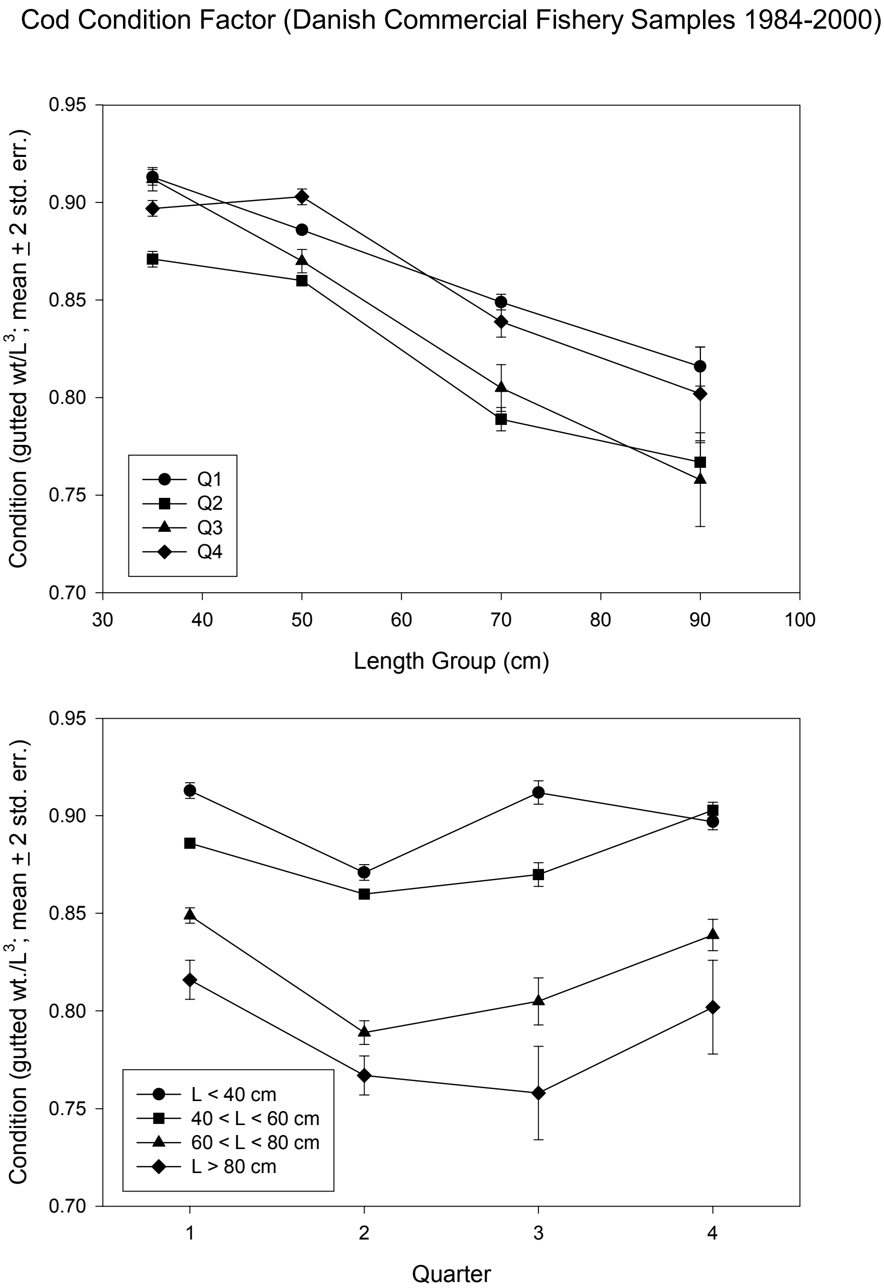


Fig. 1.4.10. Top panel. Cod condition by length – group during different quarters of the year. Bottom panel. Cod condition by quarter for different length groups. All samples from the Danish commercial fishery in the southern Baltic (mainly Subdivision 25).

Cod Condition Factor by Length and Quarter (Danish Commercial Sampling)

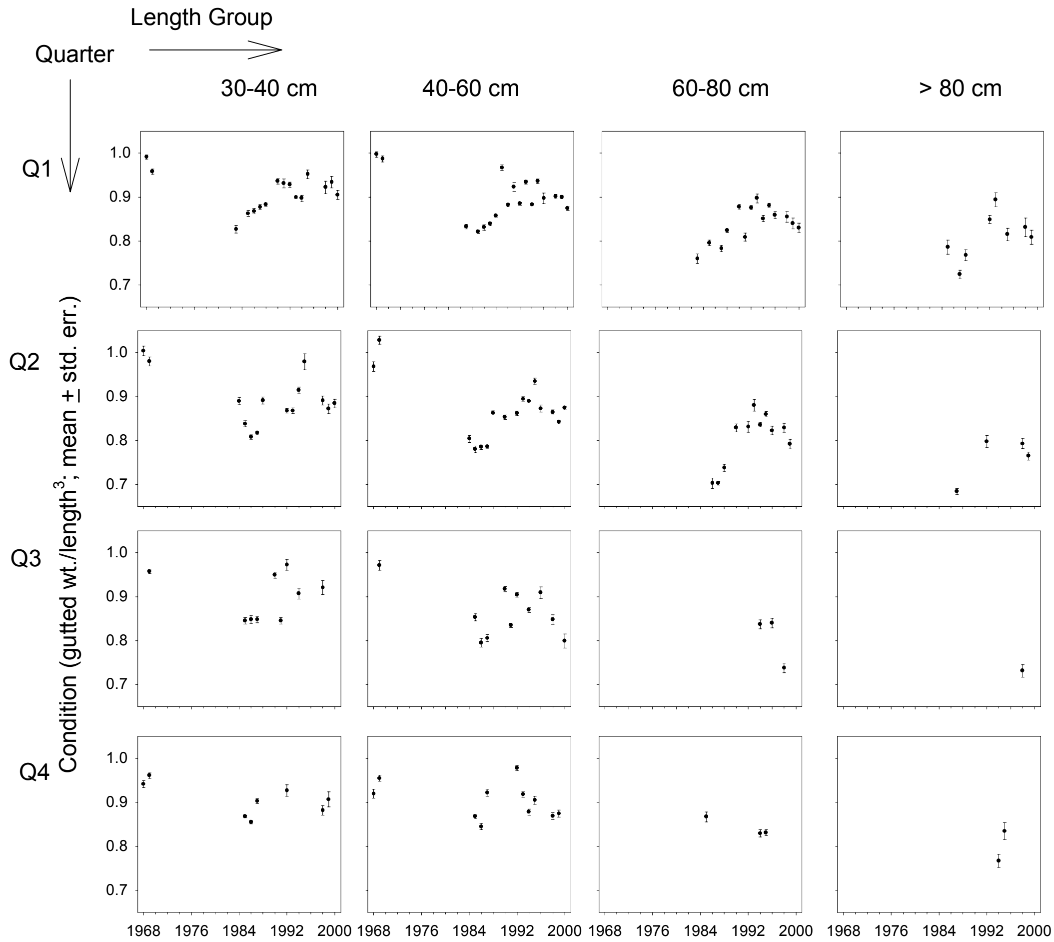


Fig. 1.4.11. Interannual variation in quarterly, length-specific condition in cod captured in the Danish commercial fishery in the southern Baltic (mainly subdivision 25).

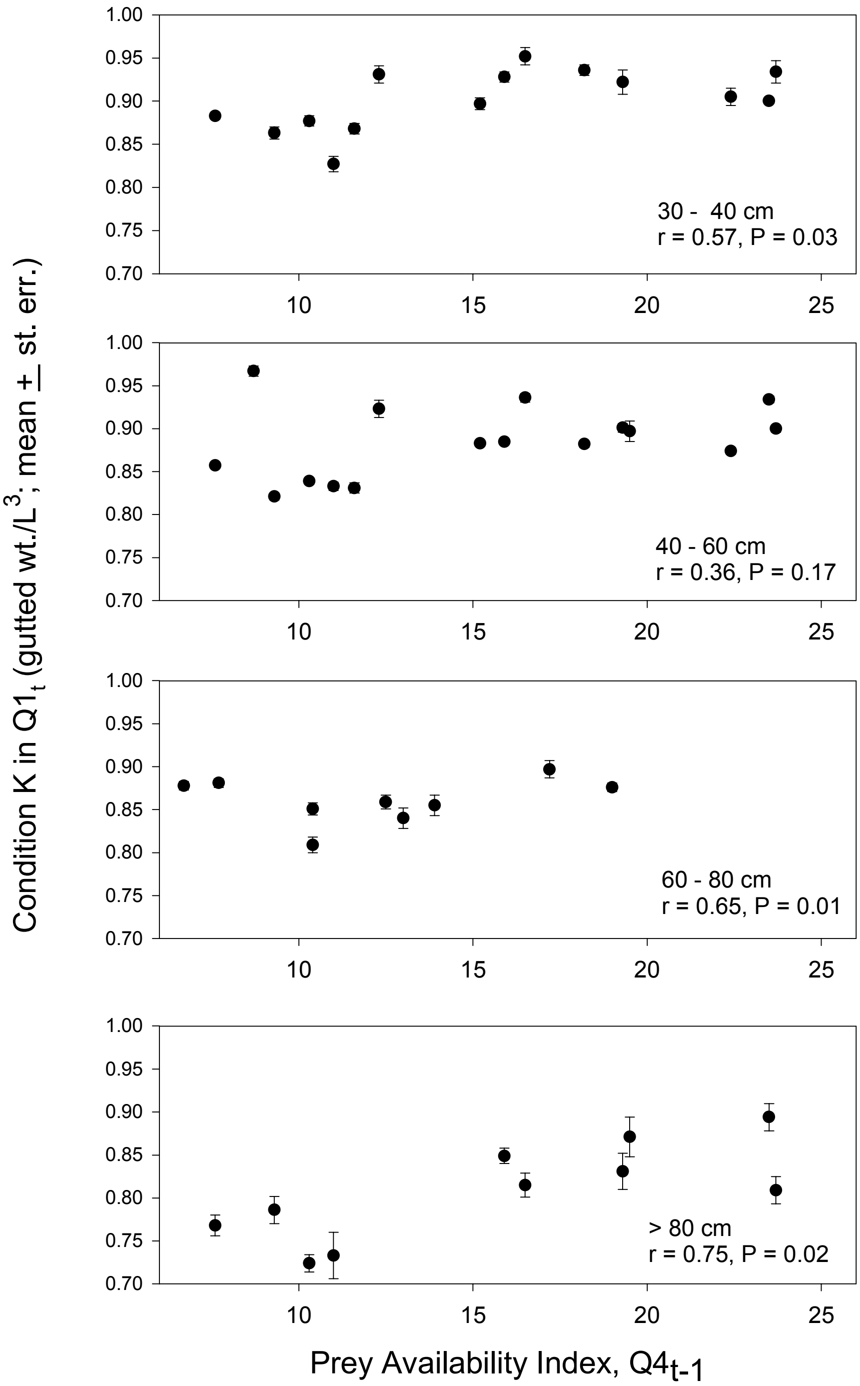


Fig. 1.4.12. Co-variation between cod condition in the southern Baltic during the first quarter and relative prey availability in the 4^{th} quarter of the previous year. The prey index is the relative herring and sprat biomass of ages 0-2 group per tonne of cod spawning biomass in subdivision 25.

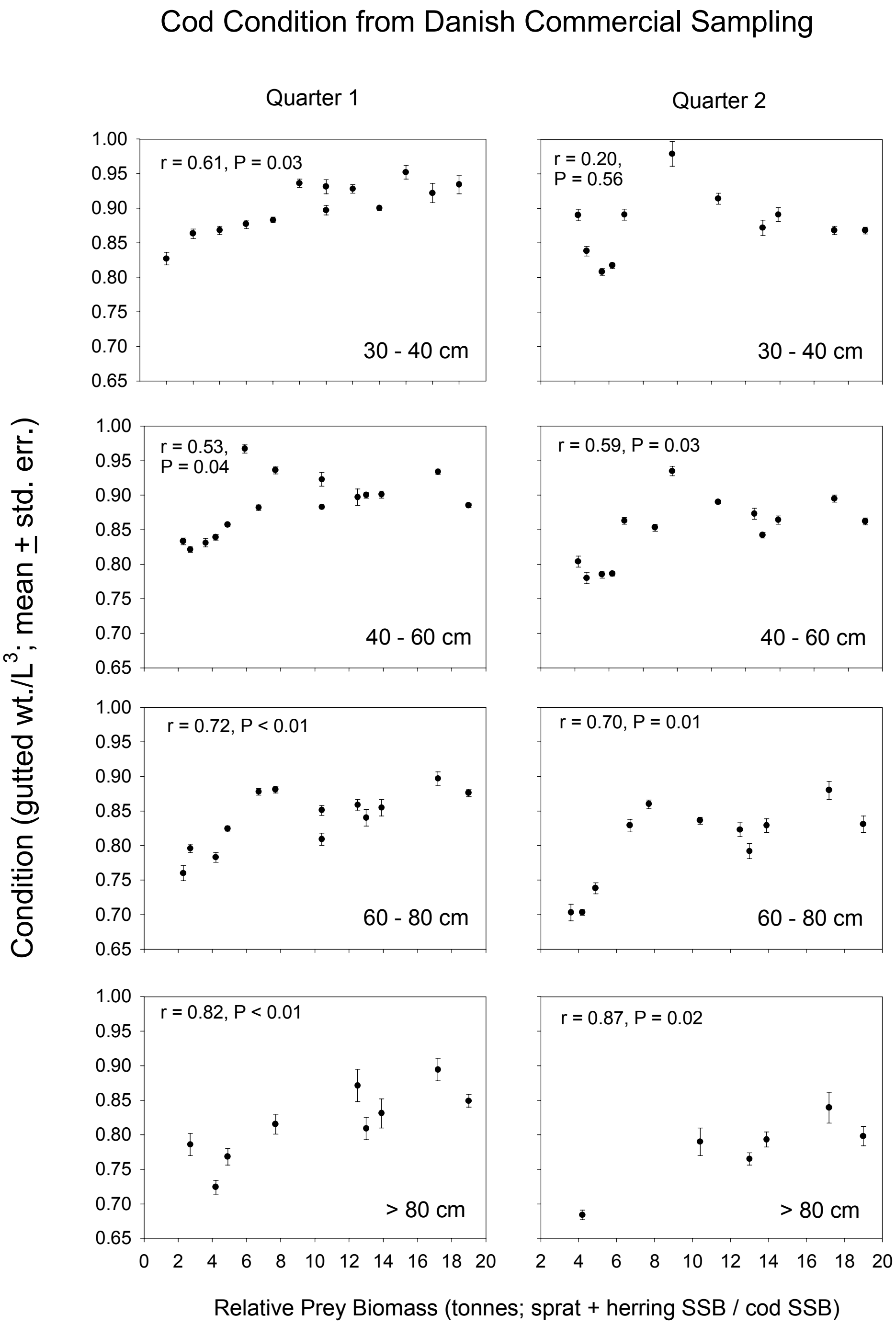


Fig. 1.4.13. Co-variation between cod condition in the southern Baltic during the first and second quarters and annual relative prey biomass in the Baltic. The relative prey biomass index is the sprat and herring spawner biomass / cod spawner biomass; sprat, herring and cod biomasses are from areas 22-32, 25-29+32 and 25-32 respectively (ICES 2000).

Finnish Commercial Cod Catches: Fulton's K

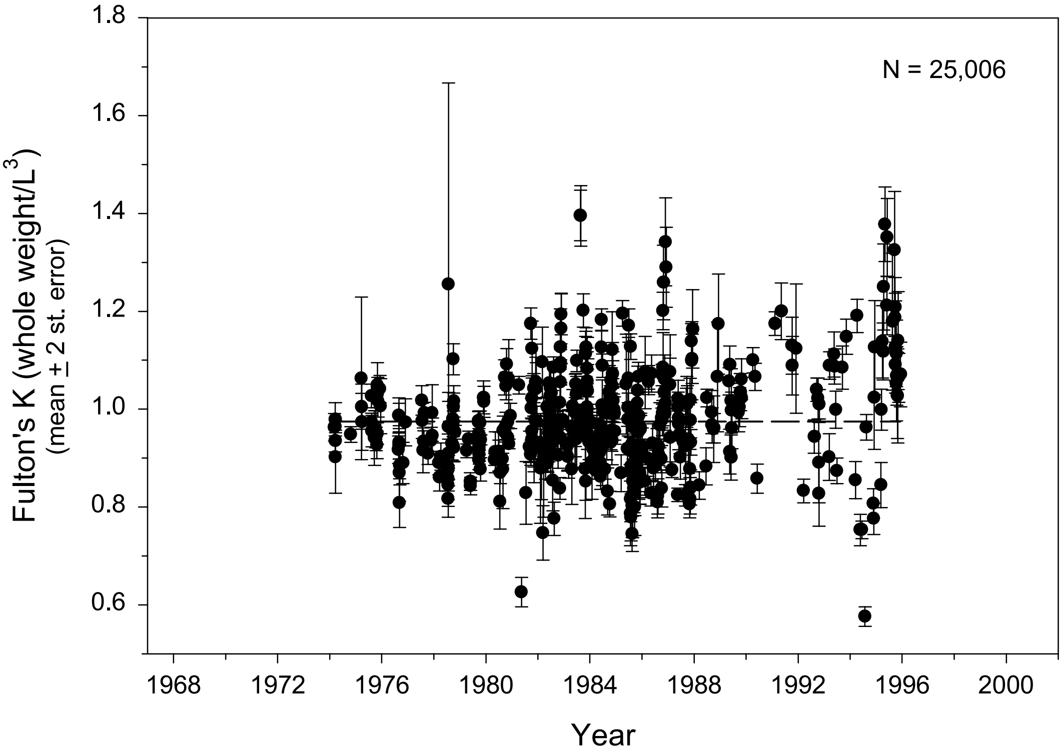


Fig. 1.4.14. Estimates of cod condition (100 x whole weight/Length^3) based on paired length and weight measurements on individual fish captured by the Finnish commercial fishery. Measurements were made on cod captured in ICES Sub-divisions 28-32.

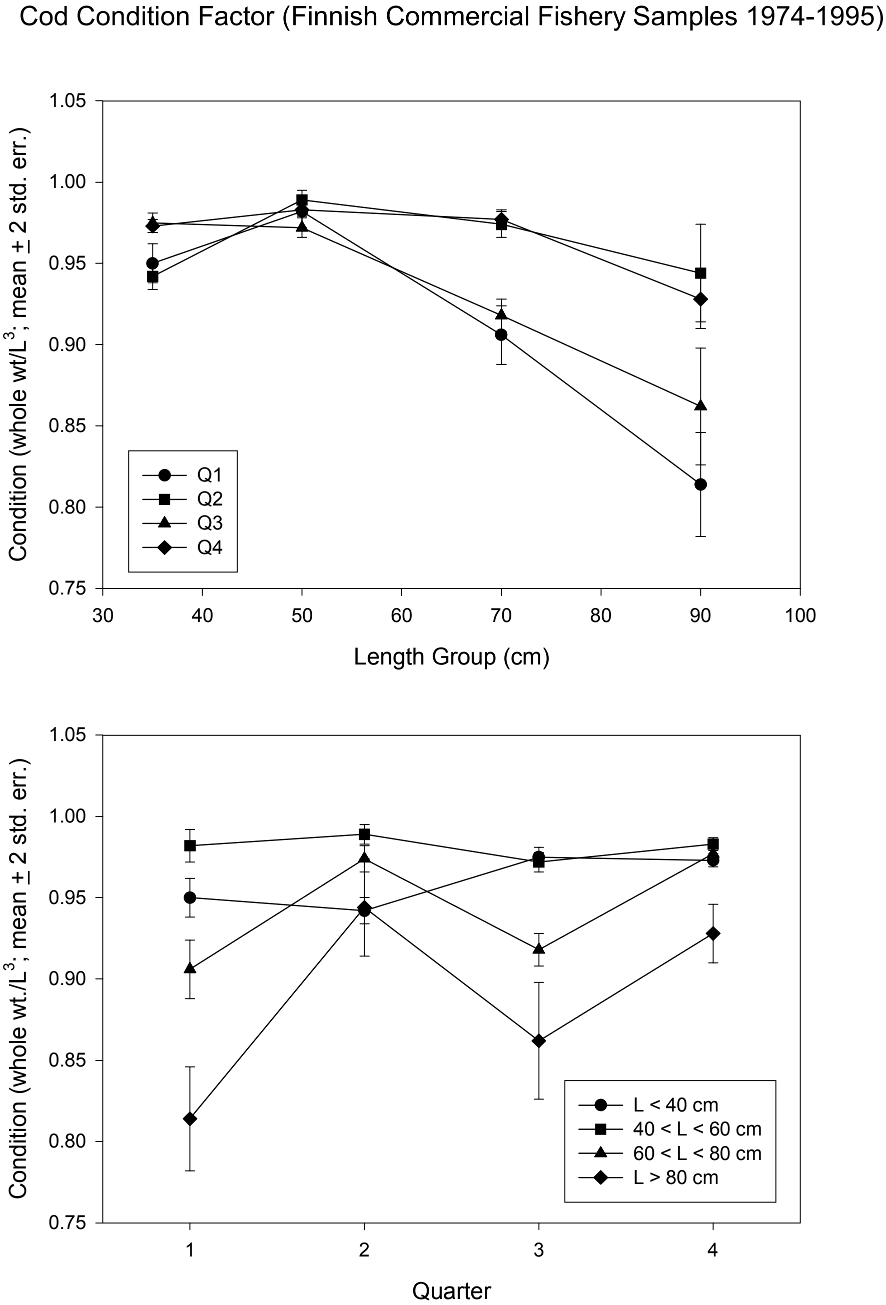


Fig. 1.4.15. Top panel. Cod condition by length – group during different quarters of the year. Bottom panel. Cod condition by quarter for different length groups. All samples from the Finnish commercial fishery in the northern Baltic (subdivision 28-32).

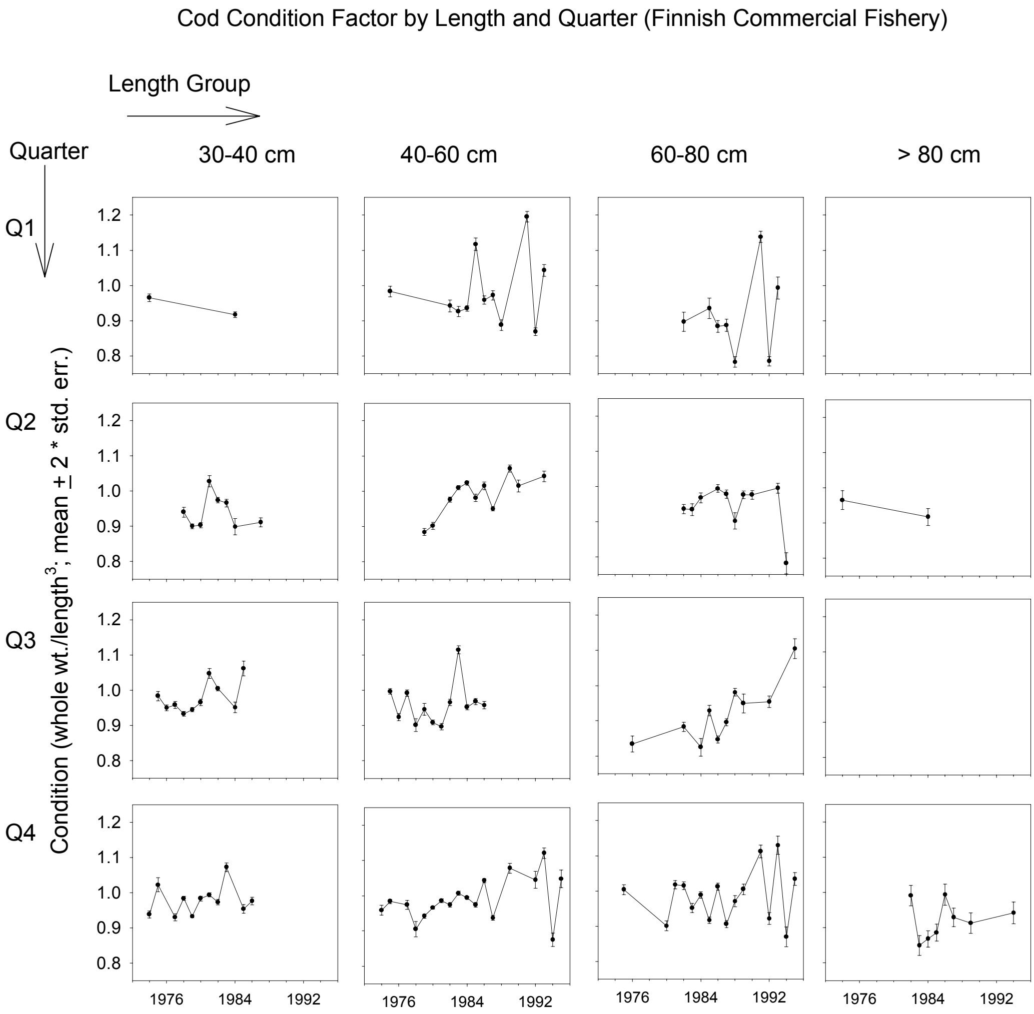


Fig. 1.4.16. Interannual variation in quarterly, length-specific condition in cod captured in the Finnish commercial fishery in the northern Baltic (subdivisions 28-32).

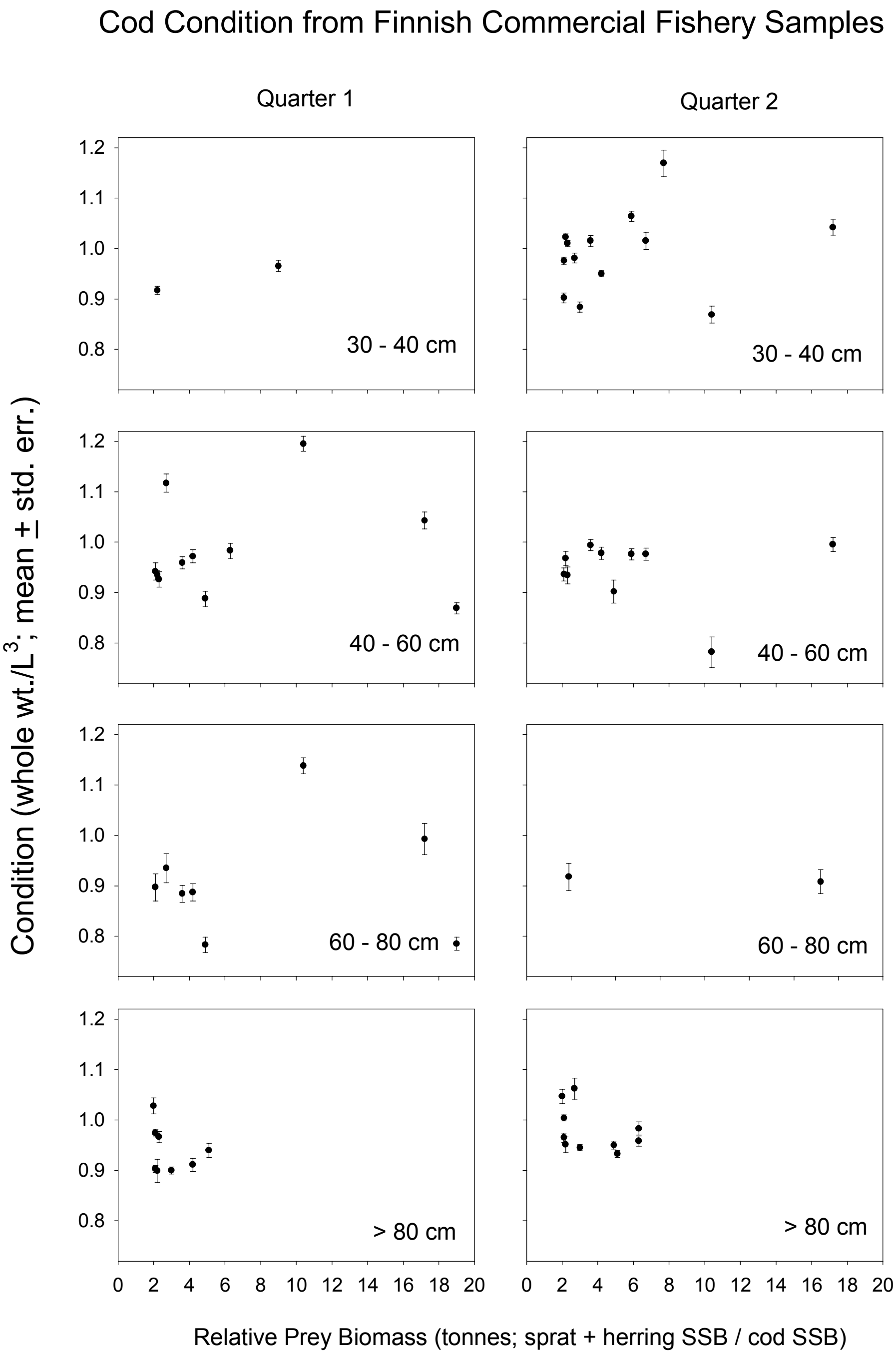


Fig. 1.4.17. Co-variation between cod condition in the northern Baltic (subdivisions 28-32) during the first and second quarters and annual relative prey biomass in the Baltic. The relative prey biomass index is the sprat and herring spawner biomass / cod spawner biomass; sprat, herring and cod biomasses are from areas 22-32, 25-29+32 and 25-32 respectively (ICES 2000).

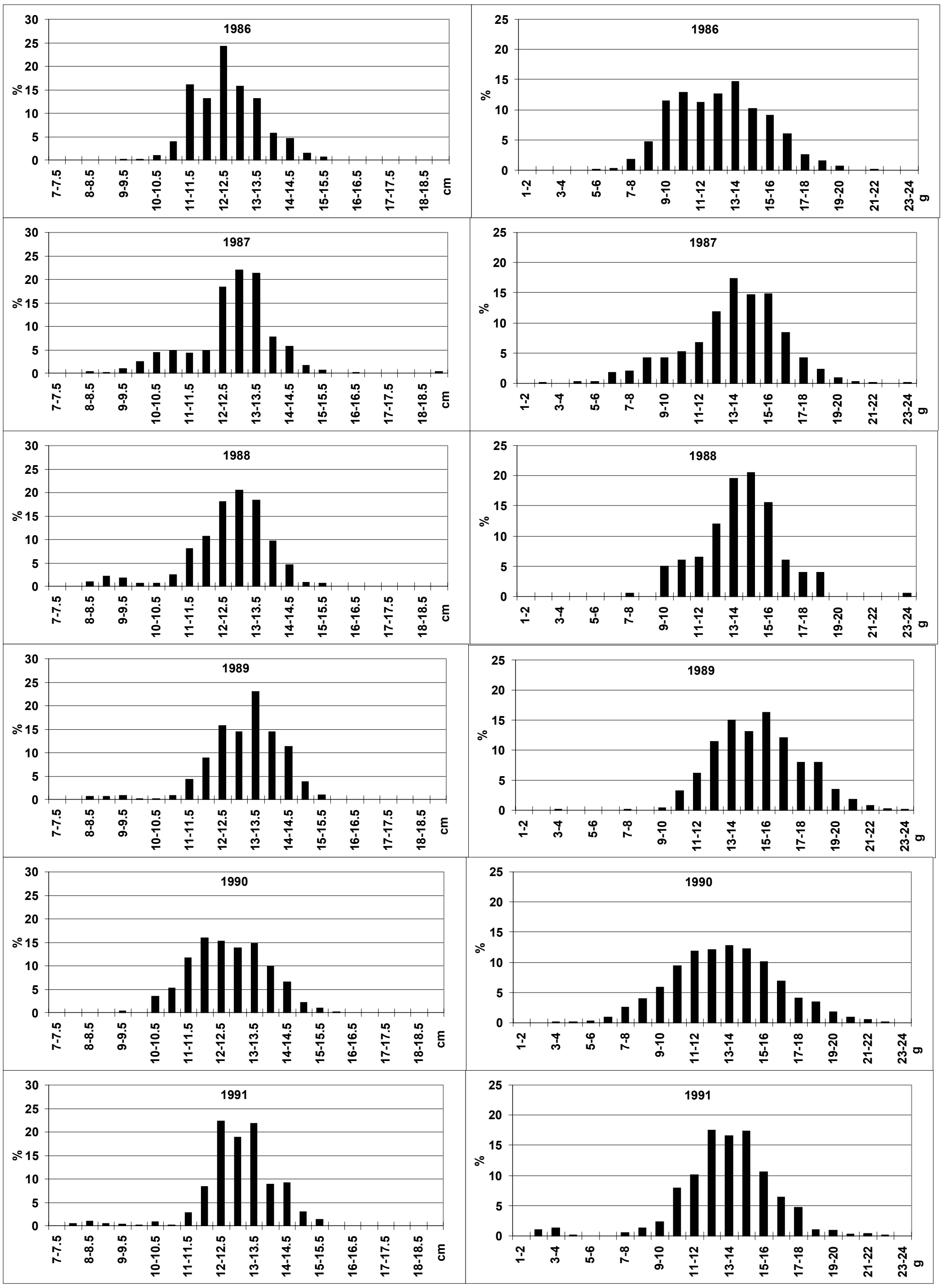


Fig. 1.4.18. The length and weight structure of Baltic sprat (%) in the Gulf of Finland in 1986-97.

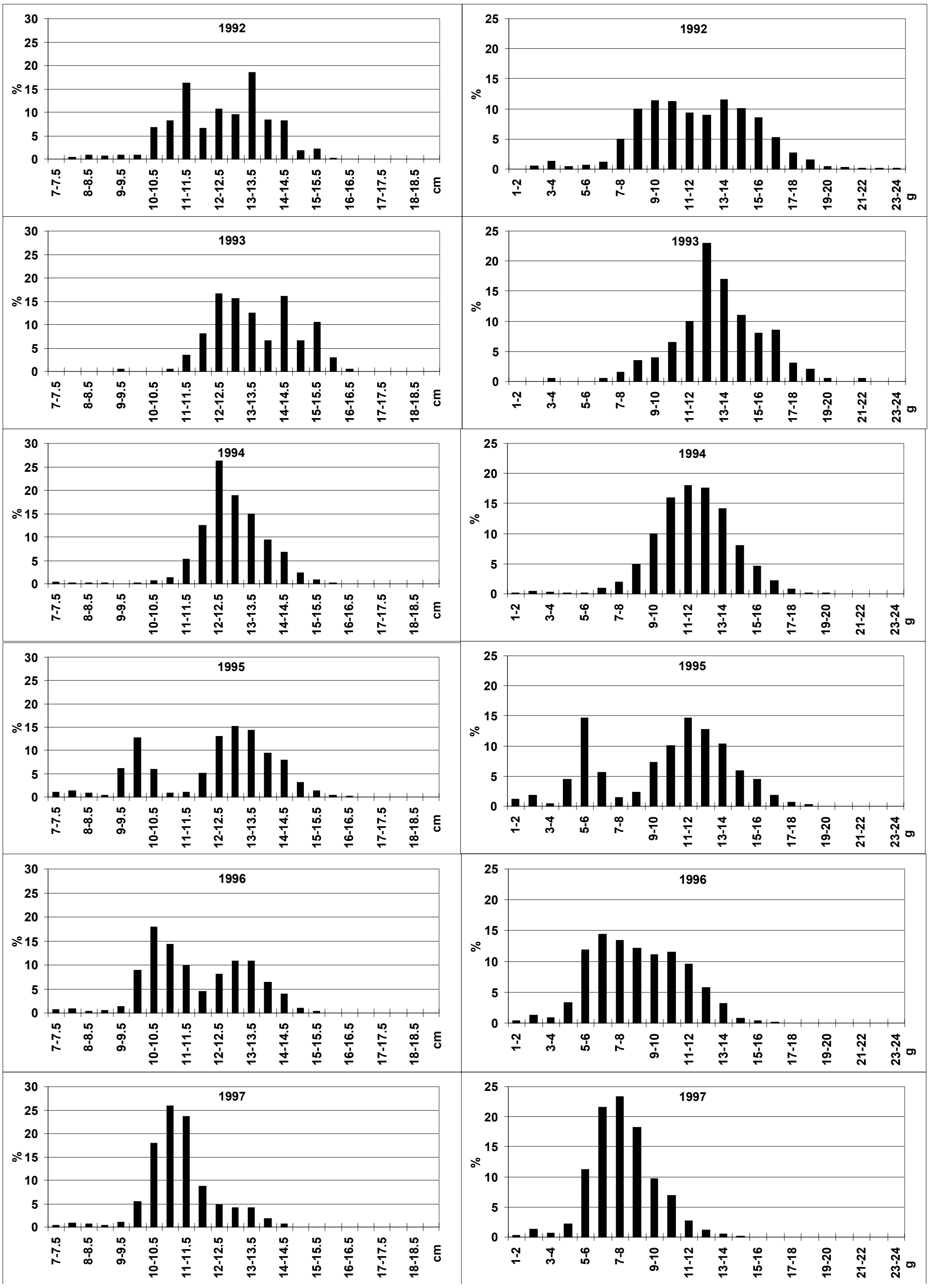


Fig. 1.4.18. continued

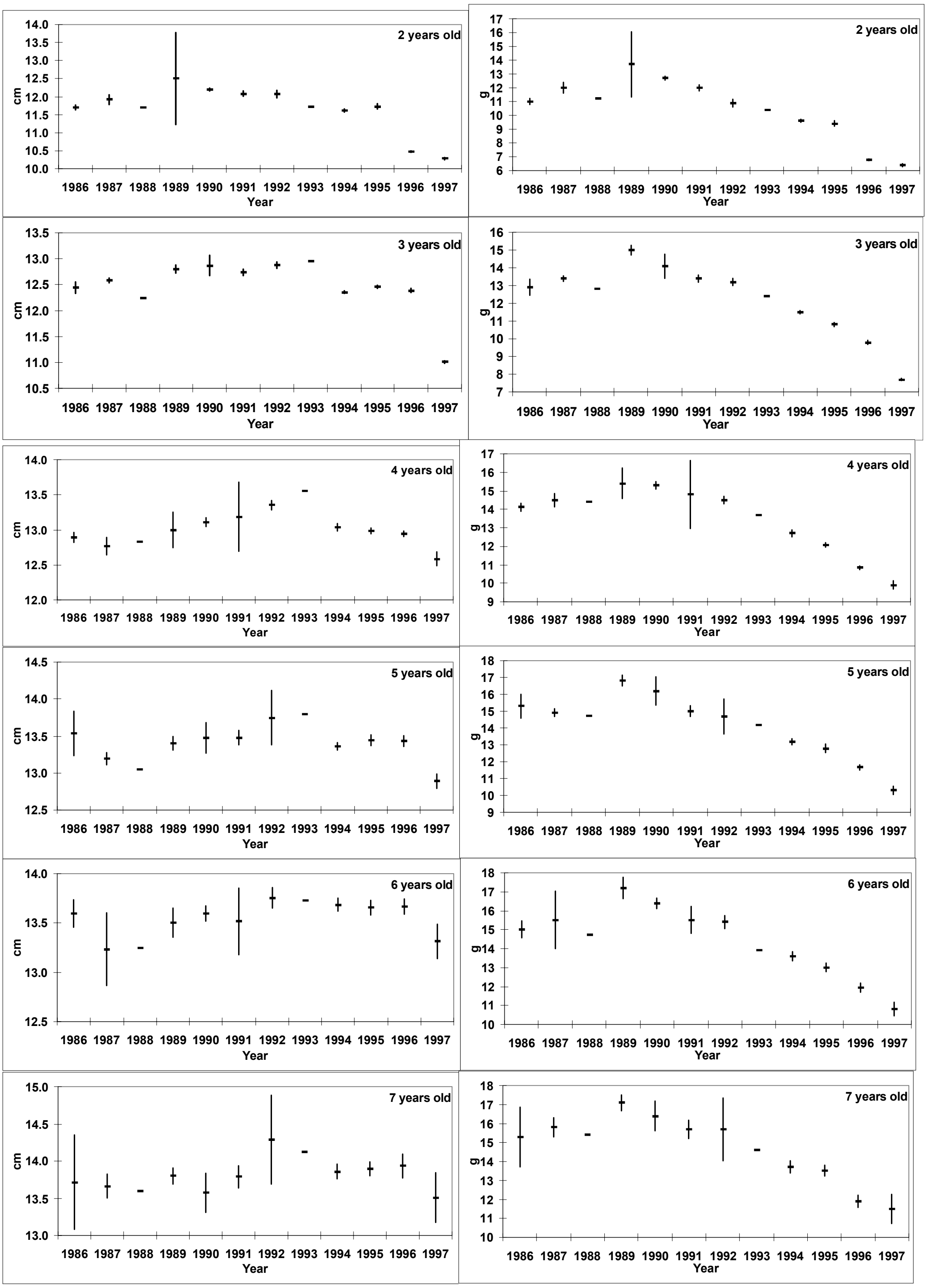


Fig. 1.4.19. The dynamics of mean length and weight of Baltic sprat at age with 95% confidence limits in the Gulf of Finland in 1986-97.

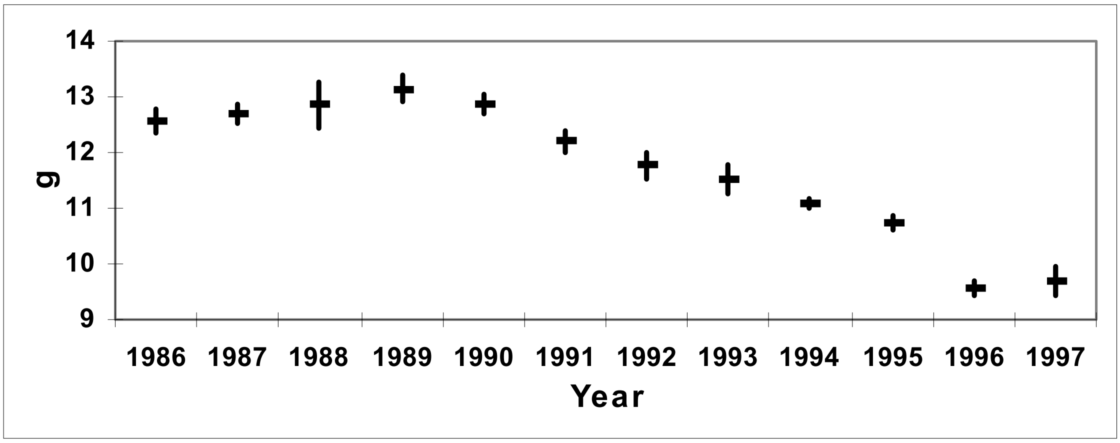


Fig. 1.4.20. The mean weight of Baltic sprat belonging to the length group 12.0-12.5 cm with 99% confidence limits in the Gulf of Finland in 1986-97.

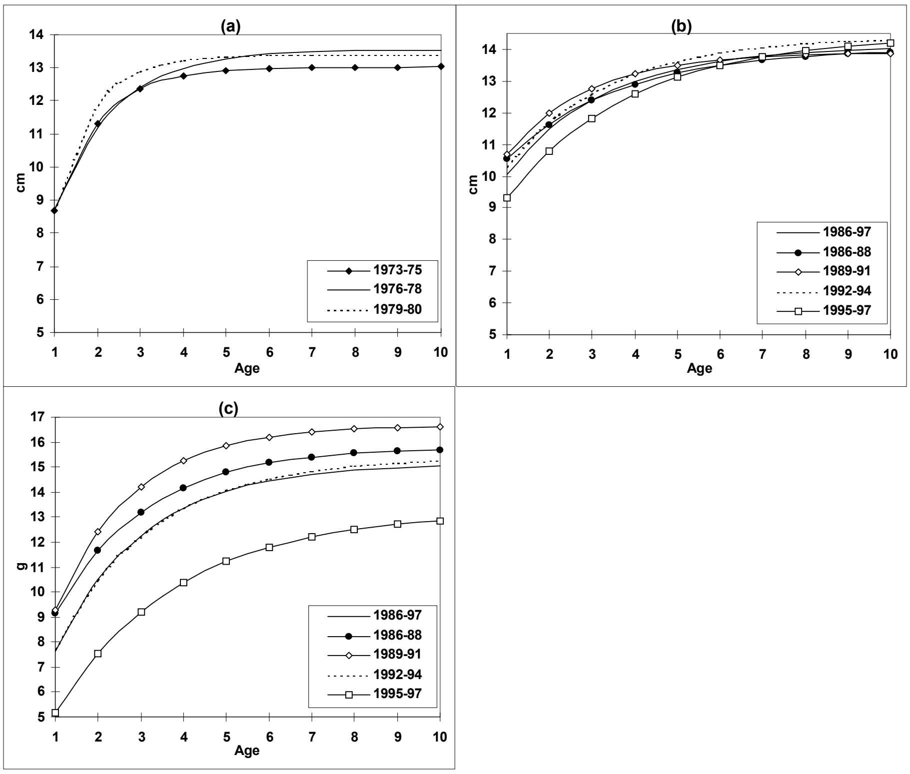


Fig. 1.4.21. The von Bertalanffy growth curves for the length (a and b) and weight (c) of Baltic sprat in the Gulf of Finland in different time intervals (a, after Aps, 1981b).

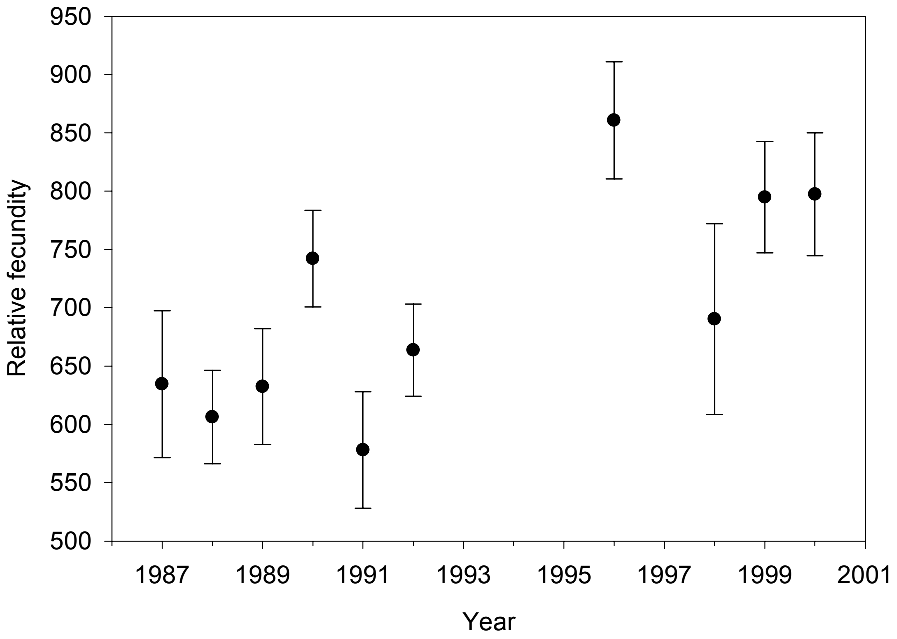


Fig. 1.4.22. Annual average relative fecundity of Baltic cod in ICES Subdivision 25 based on data from Kraus et al. (2000) and the present study. The vertical bars represent approximations of the 95% confidence limits of Tukey´s honest significant difference test for unequal sample sizes. Annual sample sizes are given in Table 1.

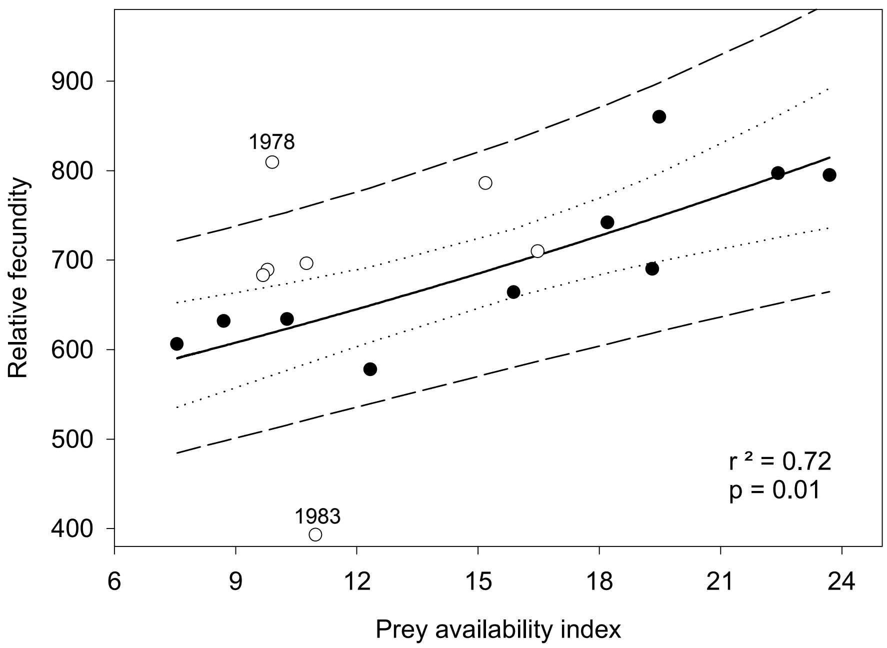


Fig. 1.4.23. Relative cod fecundity in relation to the prey availability index, P_i (sprat + herring age 0-2 biomass per unit of mature cod), in ICES Subdivision 25. Dots (●) represent data used to fit the model and circles (○) independent data from Shapiro (1988) and Bleil and Oeberst (1996). The solid line represents the 2 parameter exponential model curve, the dotted lines the 95% confidence limits and the dashed lines the prediction limits.

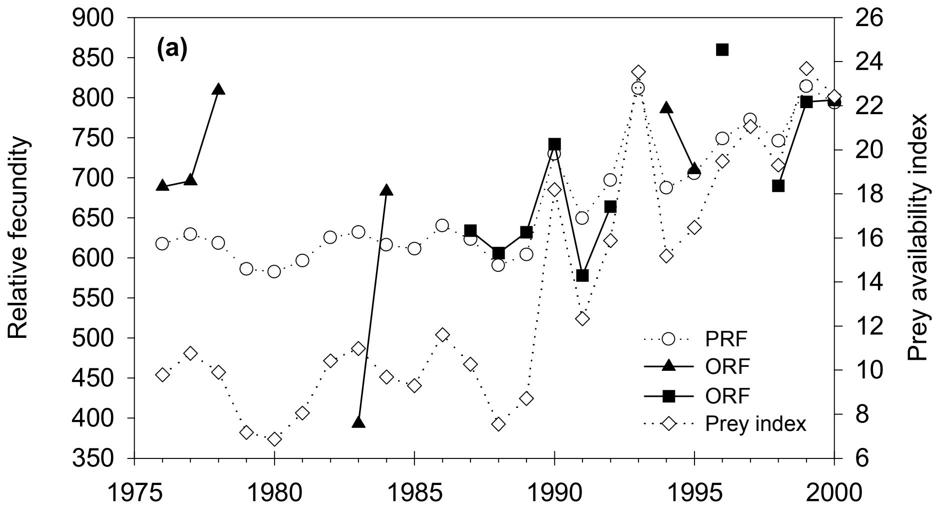


Fig. 1.4.24. Average relative cod fecundity (ORF: ■ Data from own investigations and ▲ data from Shapiro (1988) and Bleil and Oeberst (1996); PRF: Predicted from equation 1), as well as corresponding prey availability index, P_i, in relation to time.

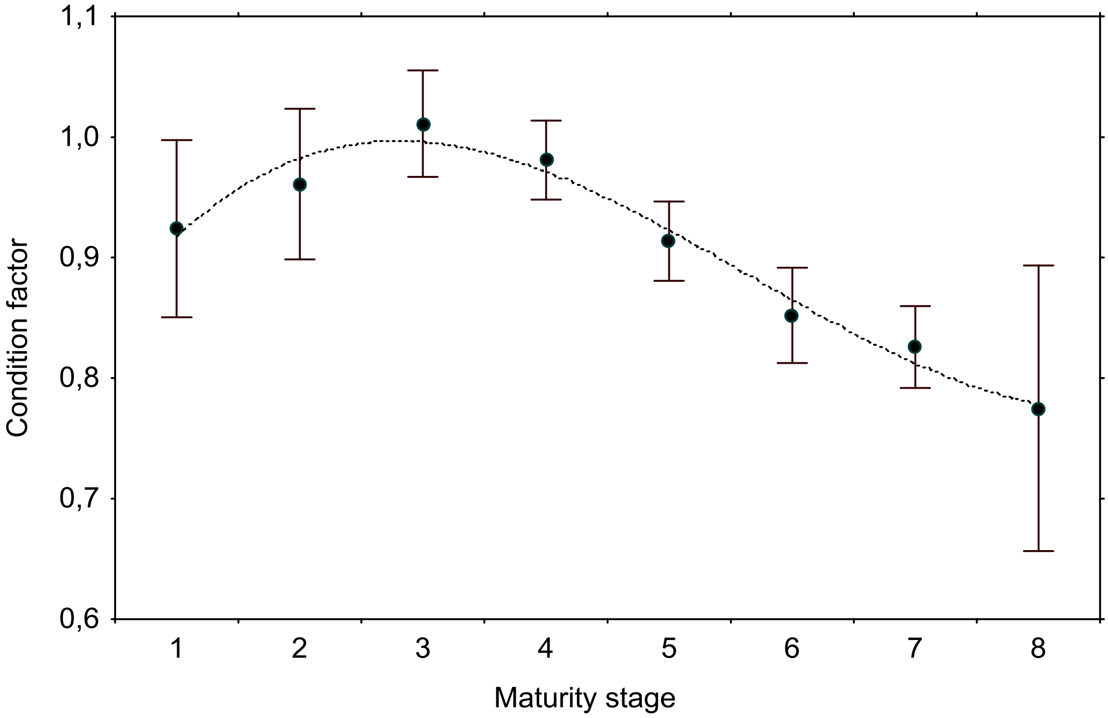


Fig. 1.4.25. Averages of Fulton's condition factor (K) of cod in relation to maturity stages and a fitted 3rd order polynomial curve. Bars indicate significance levels for Tukey's honest significant difference test for unequal sample sizes.

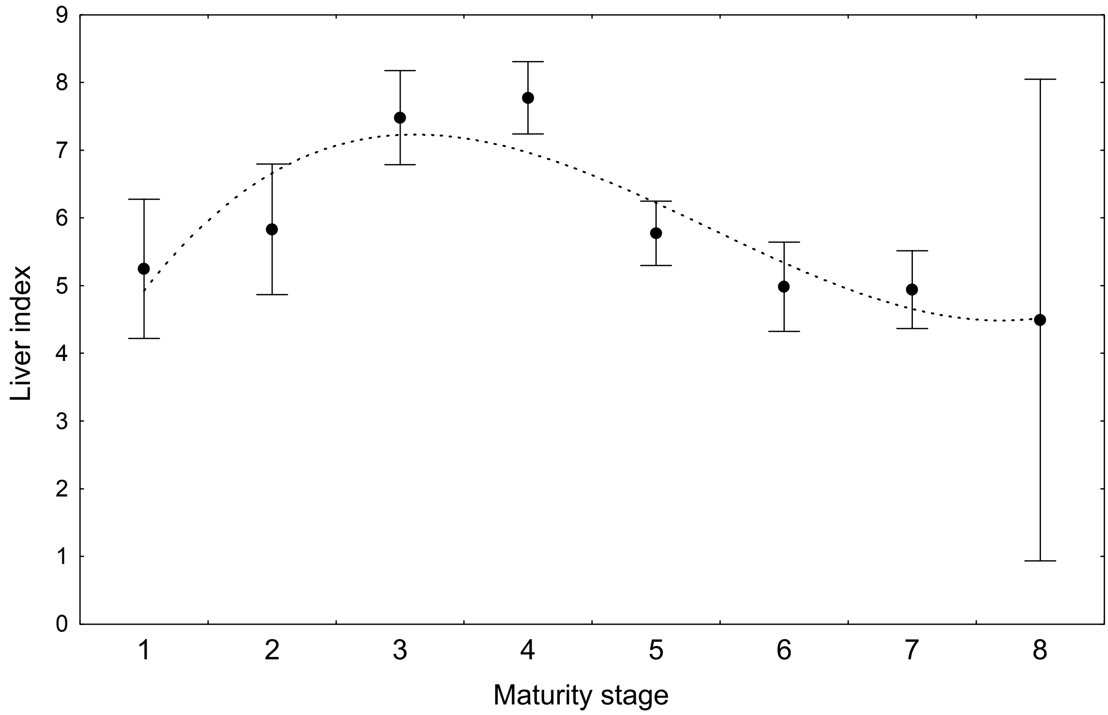


Fig. 1.4.26. Average cod liver index (HSI) in relation to maturity stages and a fitted 3rd order polynomial curve. Bars indicate significance levels for Tukey's honest significant difference test for unequal sample sizes.

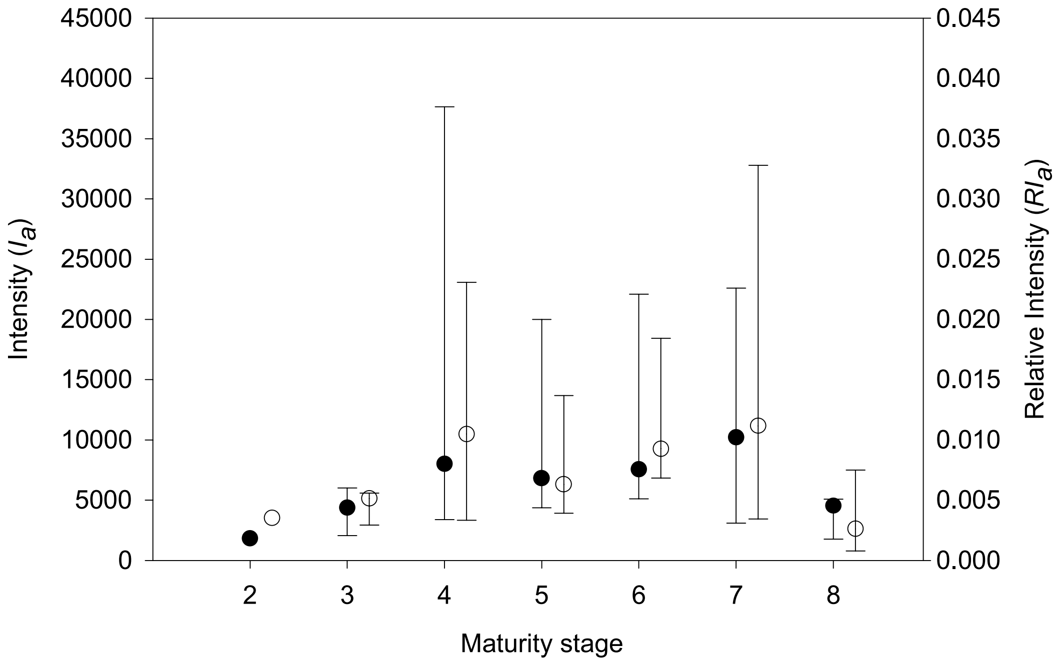


Fig. 1.4.27. Total (I_a) and relative (RI_a) intensities of cod atresia according to maturity stage. Dots (●) represent he medians of I_a, and circles (○) medians of RI_a; the bars indicate the 25% and 75% percentiles.

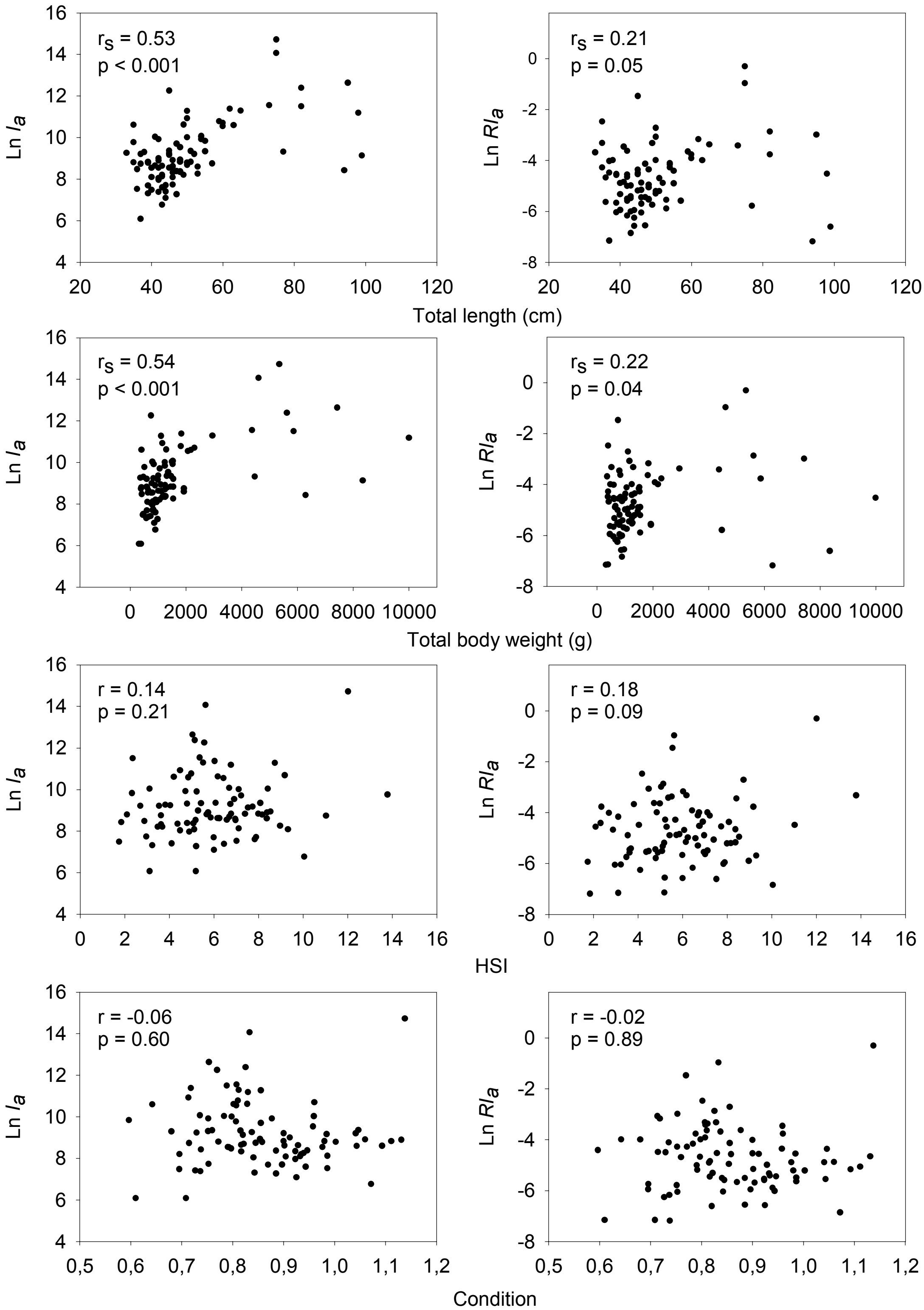
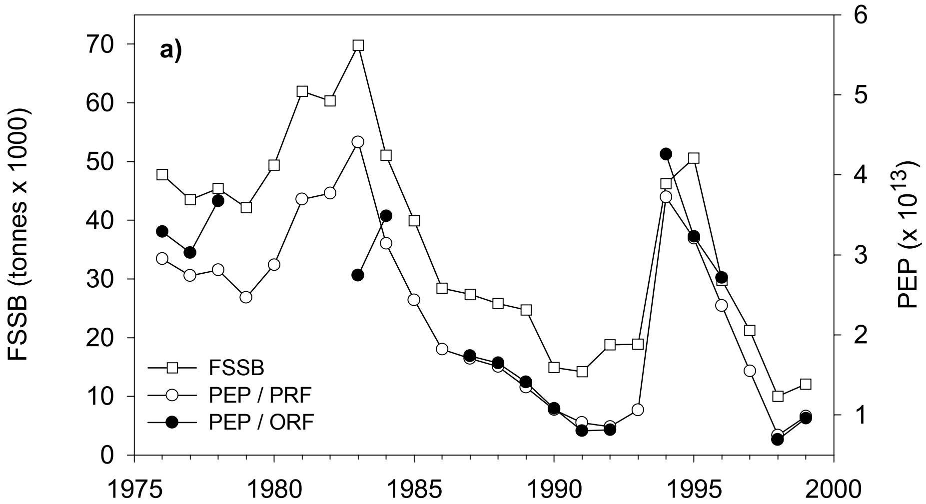


Fig. 1.4.28. Total (I_a) and relative (RI_a) intensity of cod atresia in relation to fish length, weight, liver index (HSI) and Fulton's condition factor (K). For total fish length and weight Spearman's rank correlation coefficients (rs) are given, while for condition and HSI Pearson's product moment coefficients (r) are displayed with corresponding probability values.



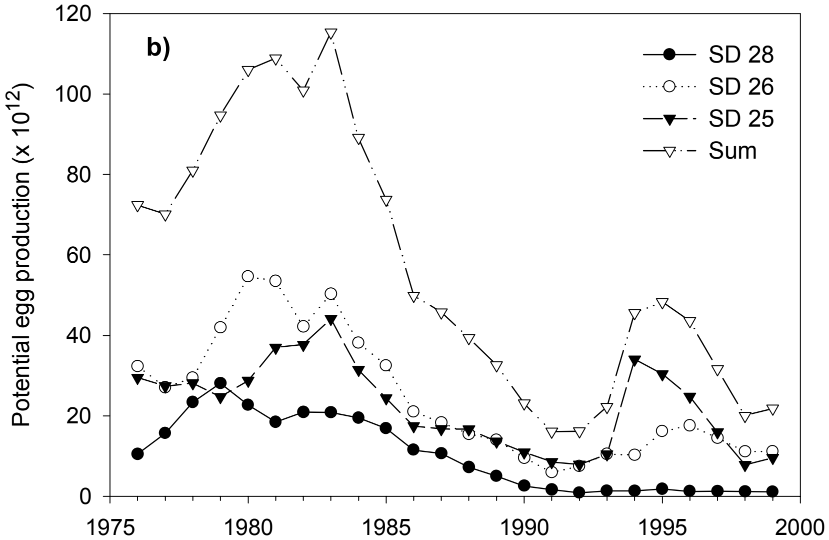


Fig. 1.4.29. (a) Time series of cod female spawning stock biomass (FSSB) in Sub-div 25, and the corresponding potential egg production estimates based on the two different fecundity series (PEP / ORF and PEP / PRF). (b) Potential egg production (PEP) per sub-division and in total for the Eastern Baltic cod stock based on area specific SSB and PRF: Predicted from equation 1) but using area specific cod and clupeid time series to establish the prey availability indices.

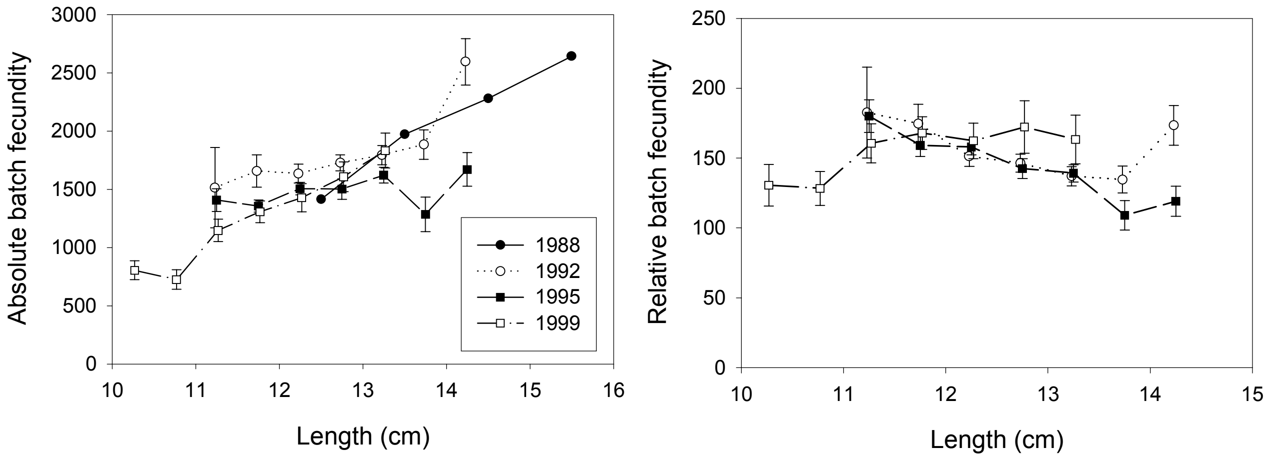


Fig. 1.4.30. Batch fecundity (left panel) and relative batch fecundity (right) of sprat in the southern Central Baltic (Sub-divisions 25 and 26) according to length with standard error in May 1988 (Müller et al. 1990), 1992, 1995 and 1999 considered are only length-classes with n ≥ 4.

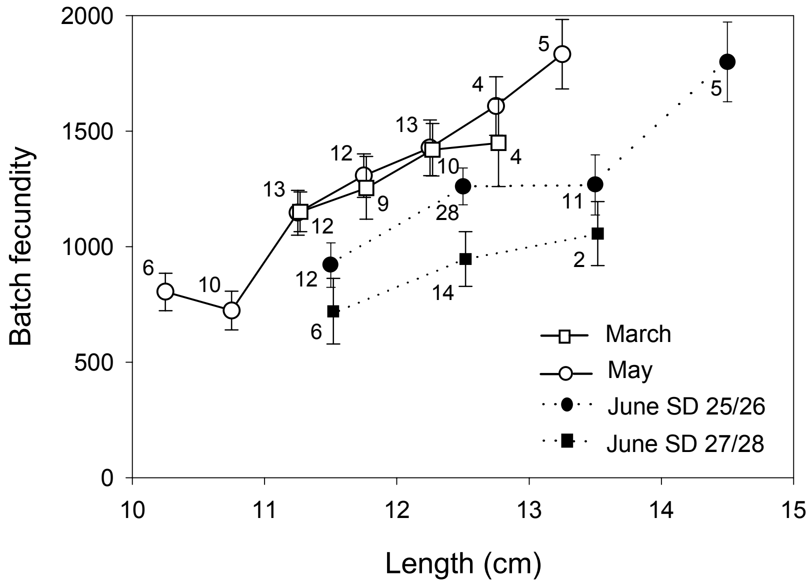


Fig. 1.4.31. Average number of eggs released per female per sprat spawning event according to length with standard error in March and May as well as June 1999 in Sub-divisions 25/26 and 27/28; numbers represent the analysed ovaries.

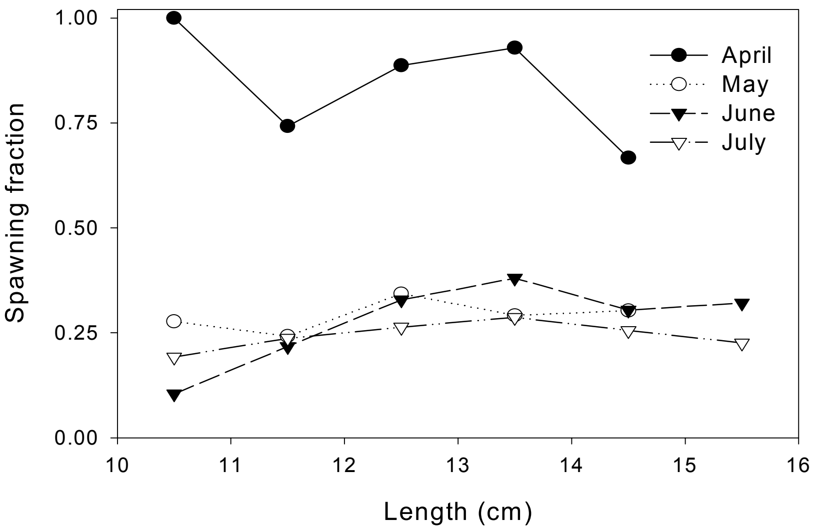


Fig. 1.4.32. Fraction of females in ripe condition that will spawn within 24 hours according to length at different months of the 1999 spawning season (from Kraus and Köster 2002).

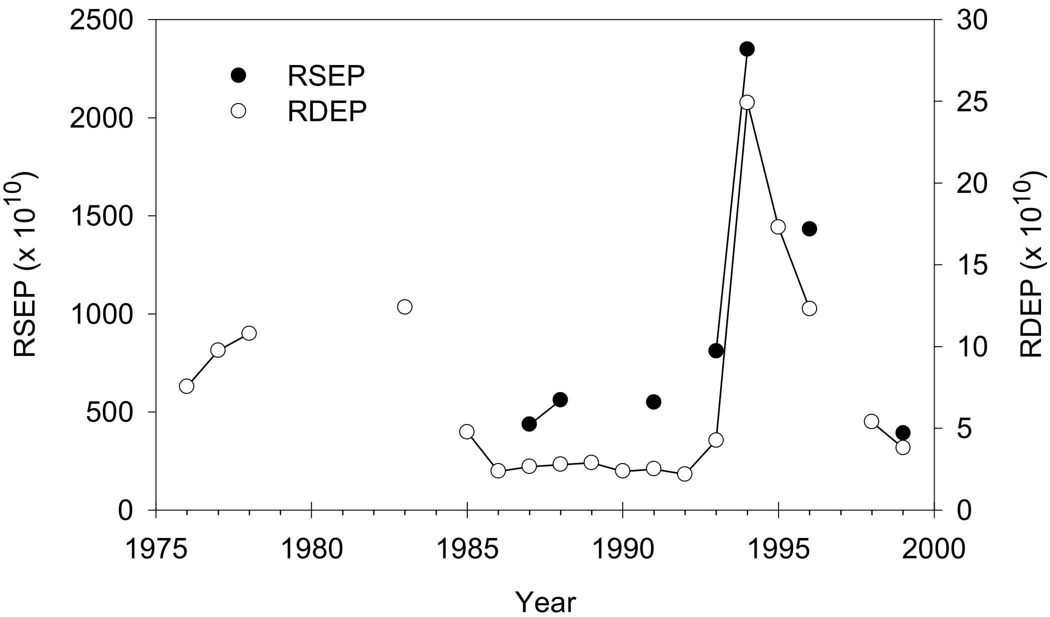


Fig. 1.5.1. Time series of realised daily egg production (RDEP) and realised seasonal egg production (RSEP) for cod in ICES Subdivision 25.

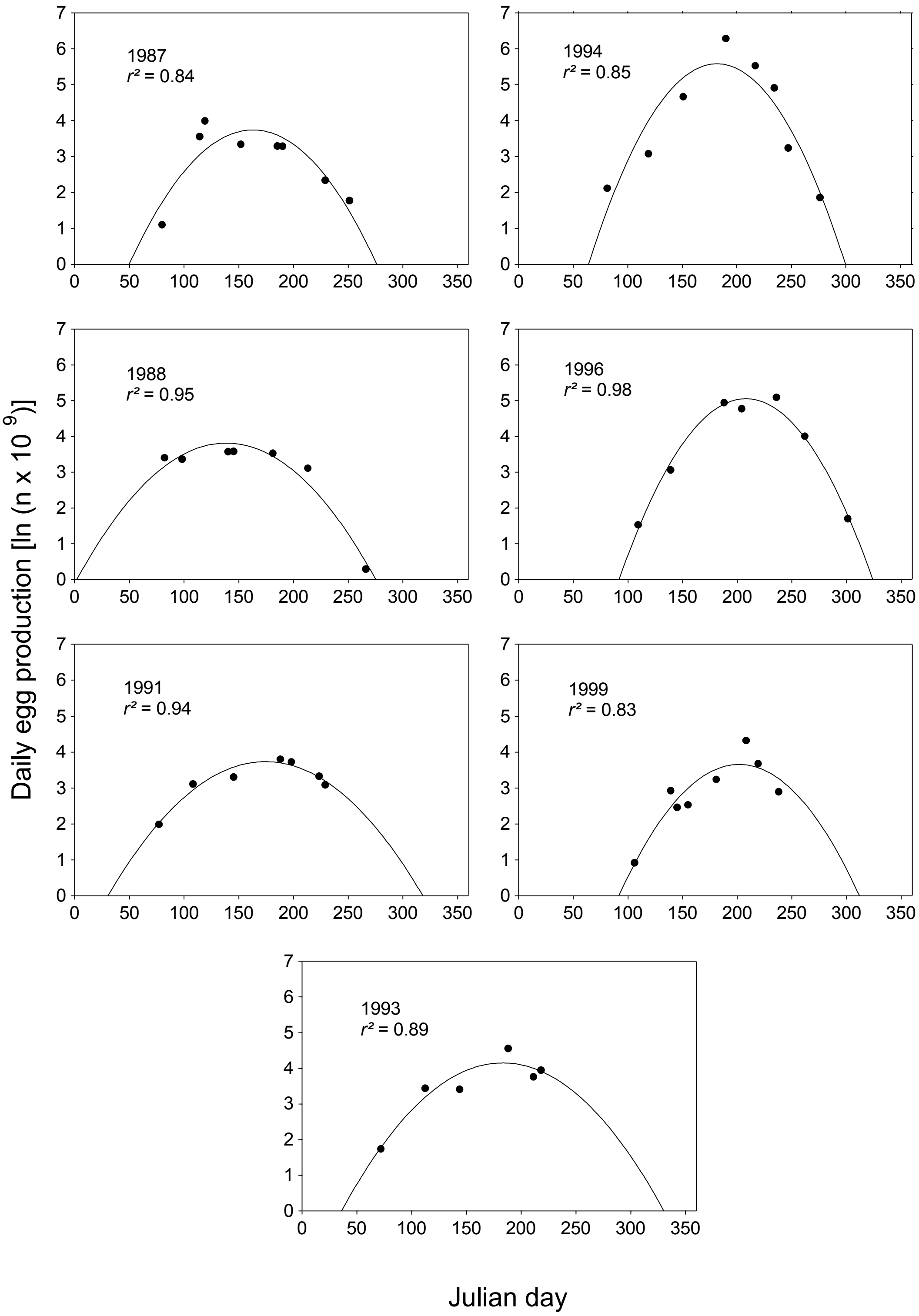


Fig. 1.5.2. Daily production of youngest egg stage (IA) of cod transformed to natural logarithms over Julian day in different years. The symbols represent the date specific production estimates and the curves second order polynomials fitted to data. The realised seasonal egg production (RSEP) is determined from the area under the curve.

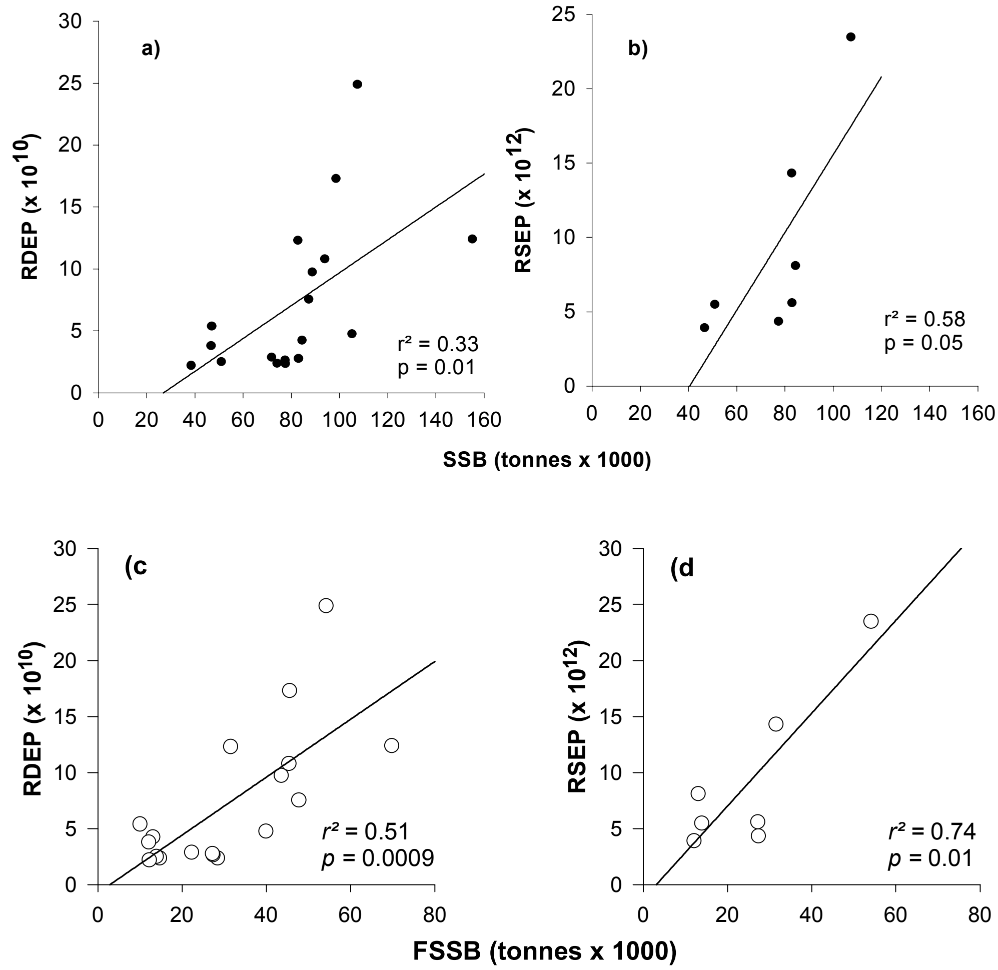


Fig. 1.5.3. Relationships between the realised cod egg production (RDEP and RSEP) and different indices of the reproductive potential, as well as explained variation and significance levels for linear regressions. The RDEP and RSEP are plotted versus (a) and (b) spawning stock biomass (SSB), (c) and (d) female spawning stock biomass (FSSB); (e) and (f)potential egg production (PEP) based on predicted relative fecundity (PRF); (g) and (h) PEP based on observed relative fecundity (ORF).

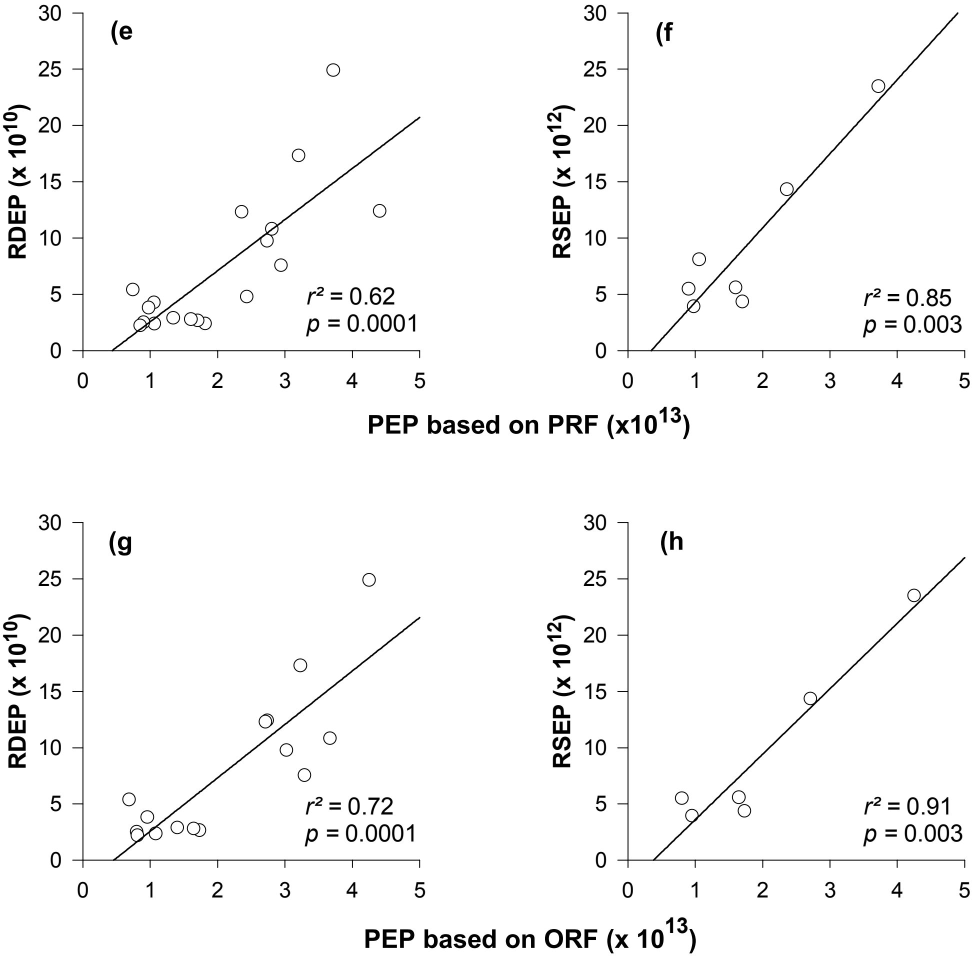


Fig. 1.5.3. (continued)

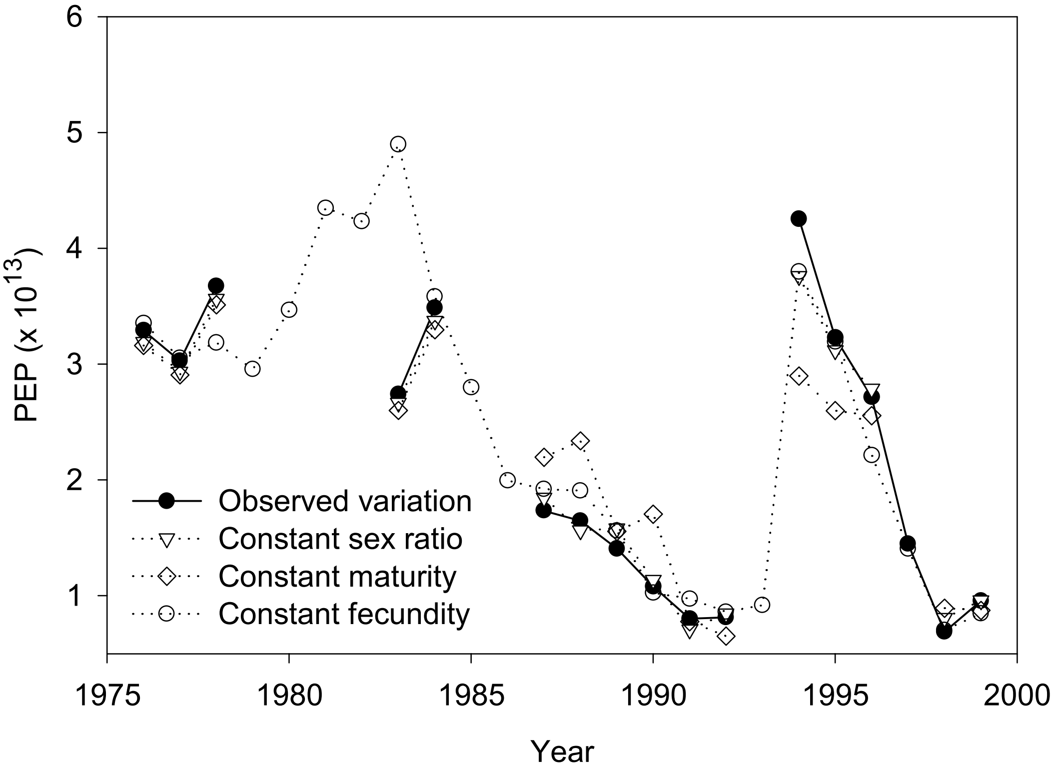


Fig. 1.5.4. Time series of potential cod egg production (PEP) based on variable time series or with constant sex ratio, maturity ogive, mean weight at age and fecundity, respectively. In time series with constant sex ratio, maturity and weight at age the ORF fecundity time series were applied, while for constant fecundity the long term average relative fecundity (PRF) was used.

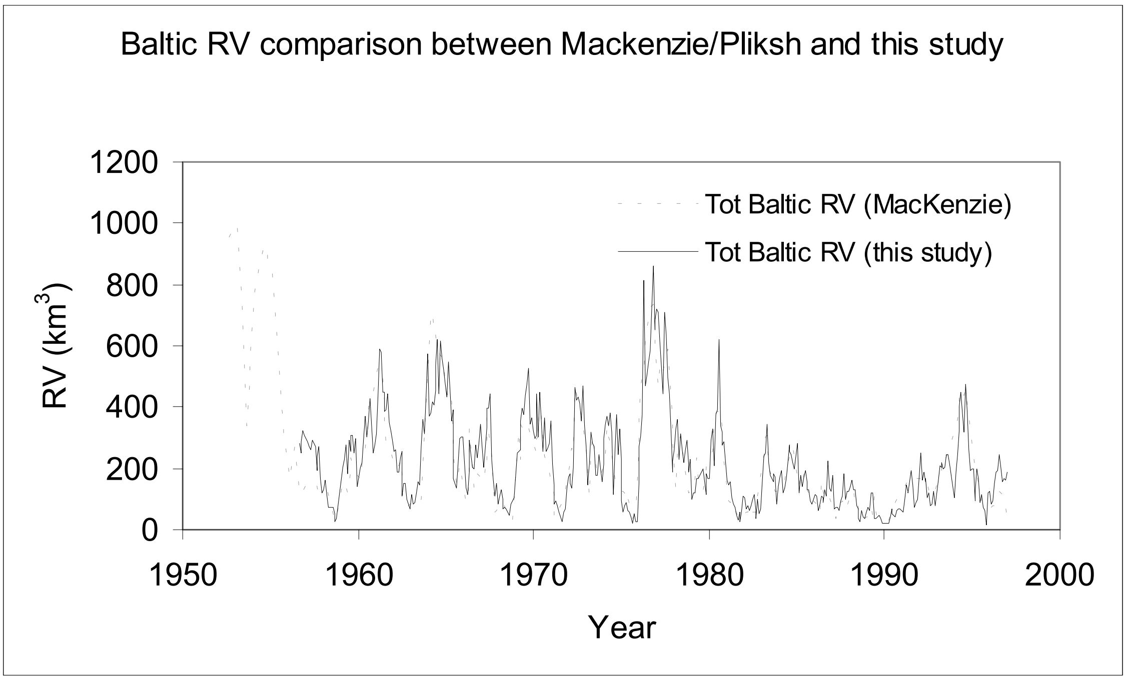


Fig. 1.5.5. Temporal comparison between the cod reproductive volume (RV) calculated in this study (1956-2000) and Plishs/MacKenzies (MacKenzie et al. 2000) RV time series (1952-1996). In both time series missing months are filled by linear interpolation.

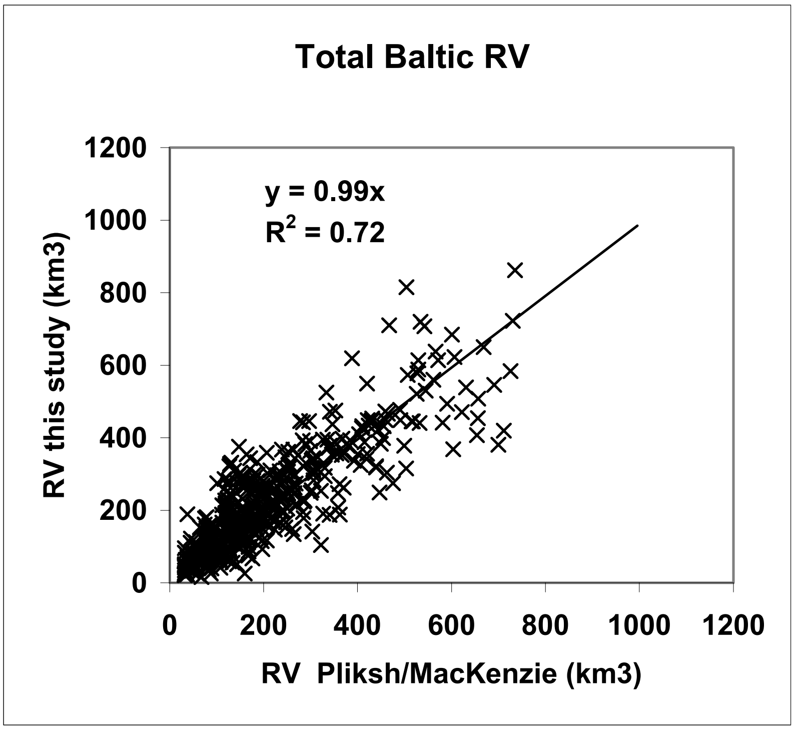
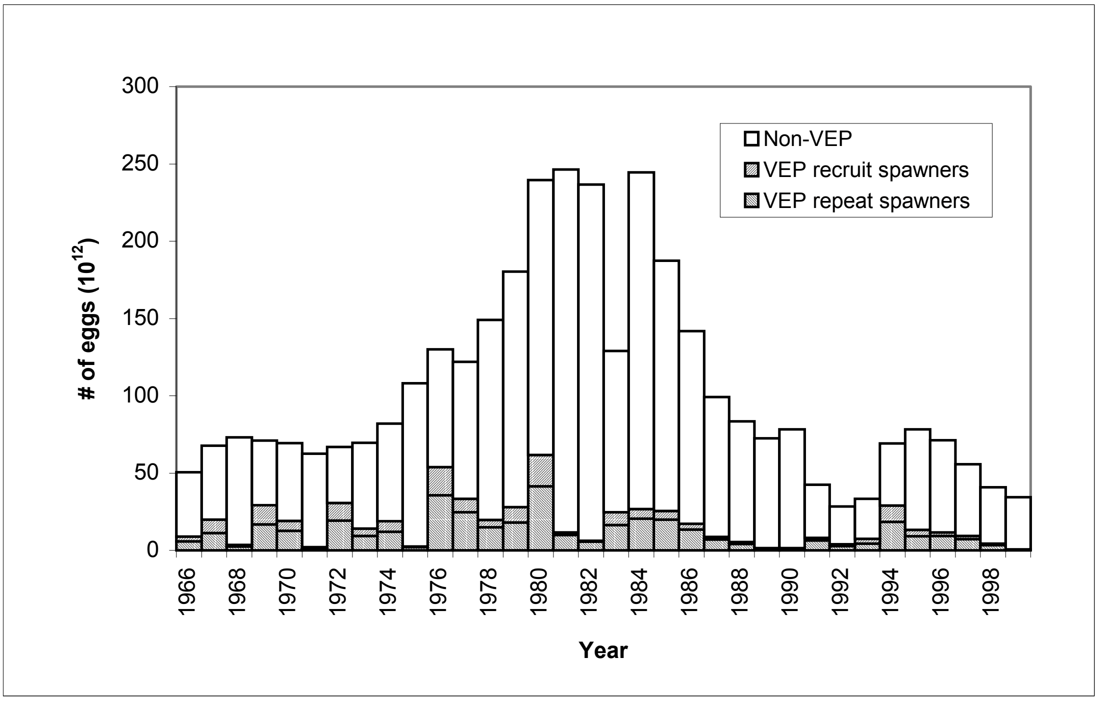


Fig. 1.5.6. The cod reproductive volumes calculated in Sub-task 1.5 versus Plikshs/MacKenzie (MacKenzie et al. 2000) with correlation coefficient and slope of the regression.

a



b

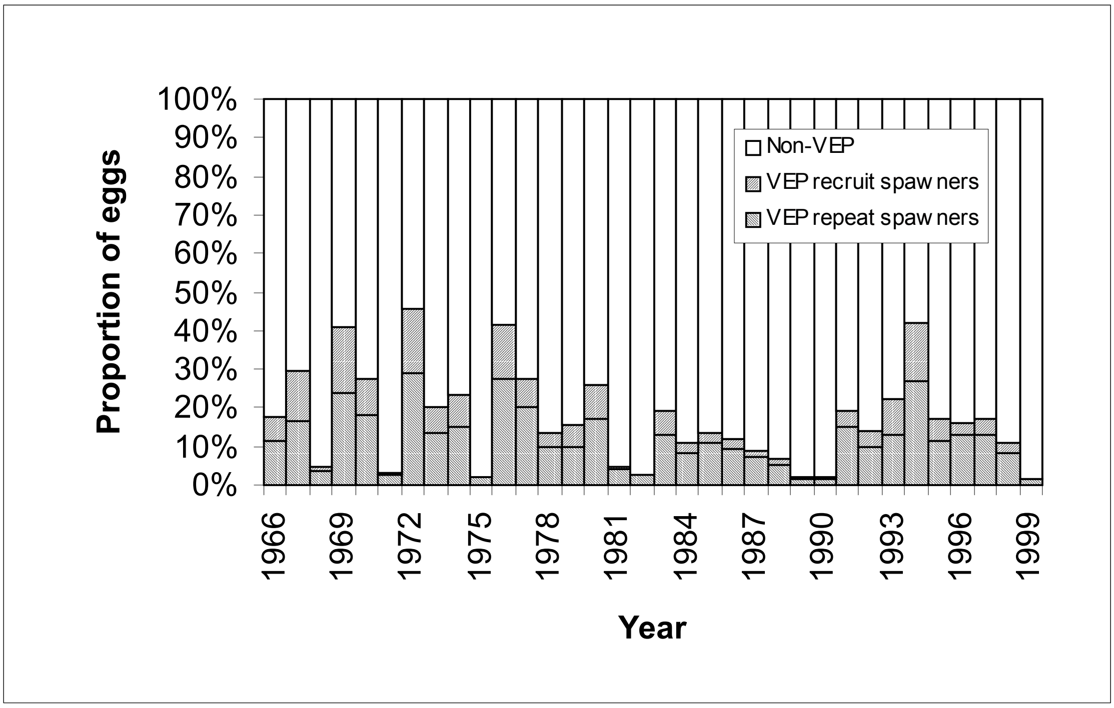


Fig. 1.5.7. The absolute (a) and relative (b) egg production (PEP) of cod separated into non-viable egg production and viable egg production (VEP) of first time spawners and repeat spawners.

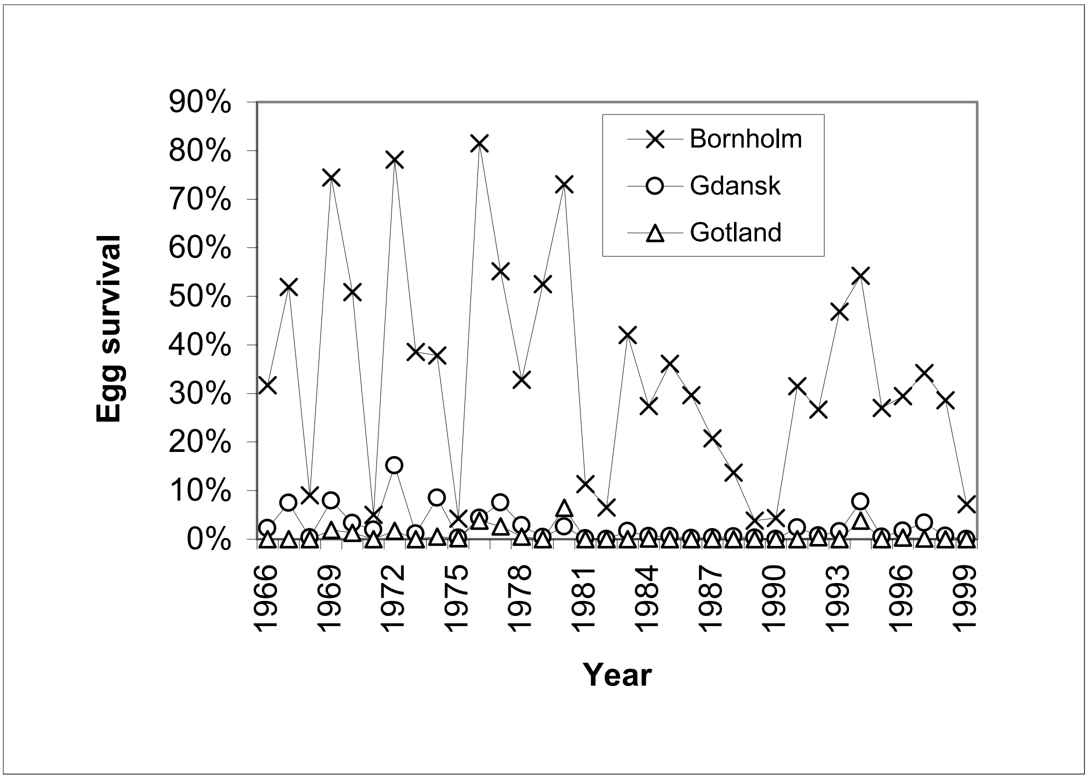


Fig. 1.5.8. The temporal development in oxygen related cod egg survival in different spawning areas between 1966 and 1999.

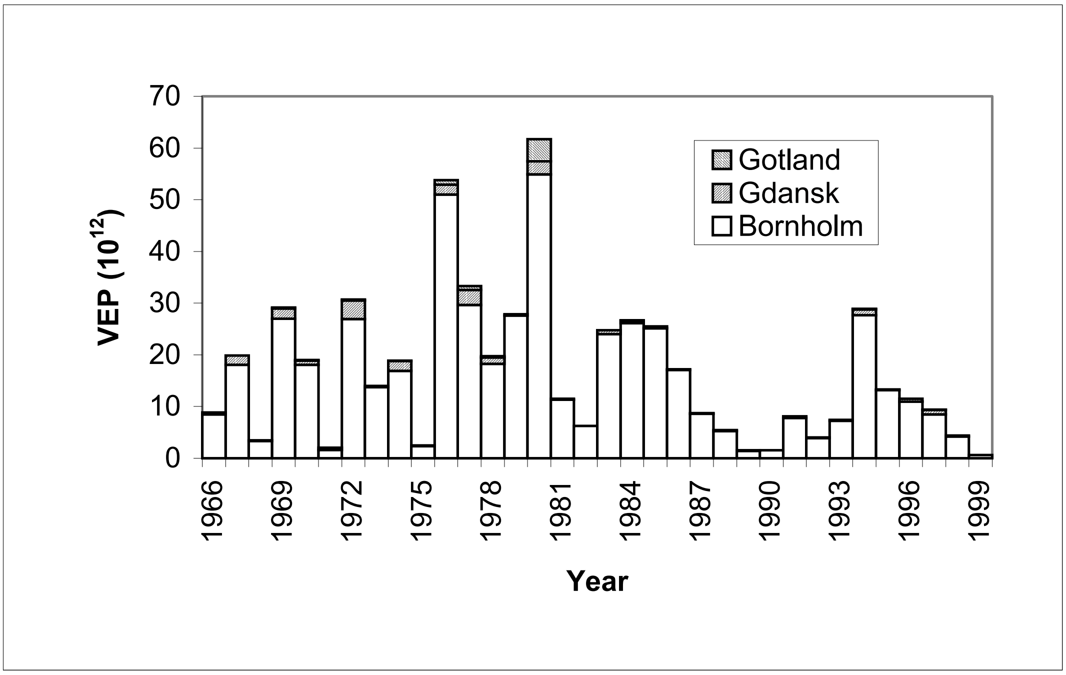


Fig. 1.5.9. The contribution to the VEP of by Sub-division.

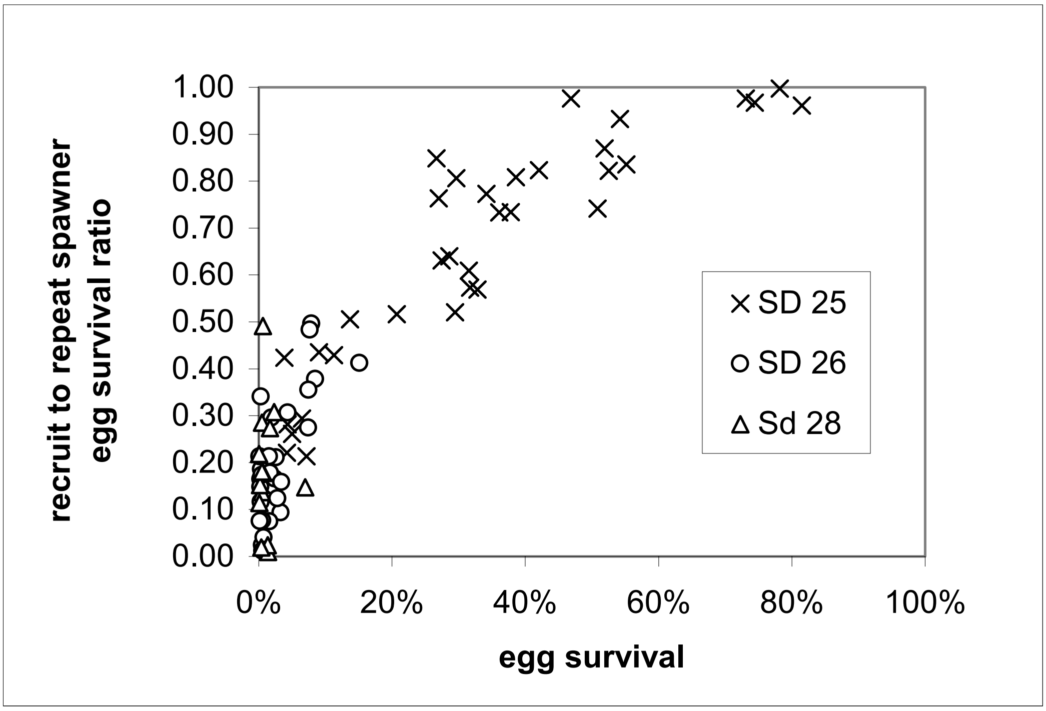
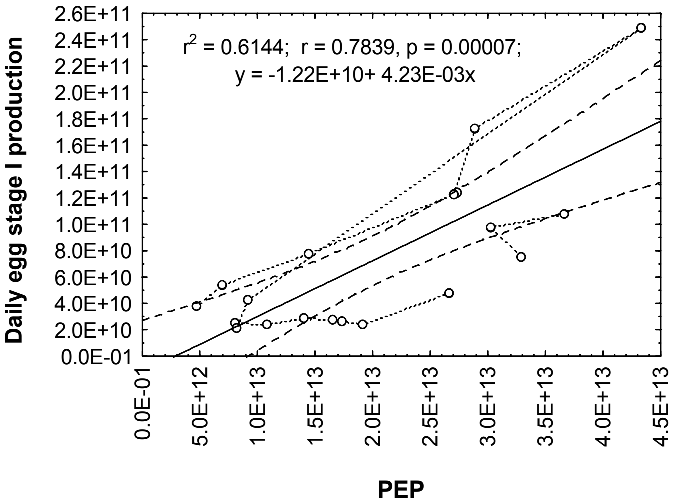
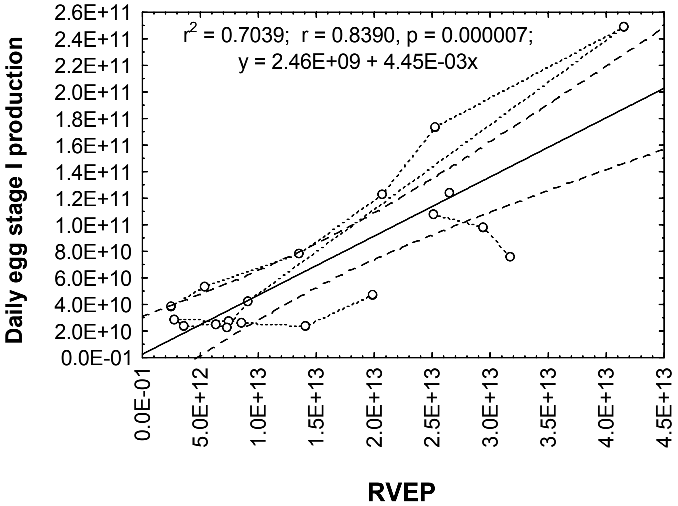


Fig. 1.5.10. Ratio between the survival of cod eggs from first time spawners to the survival of eggs from repeat spawners.

a



b



c

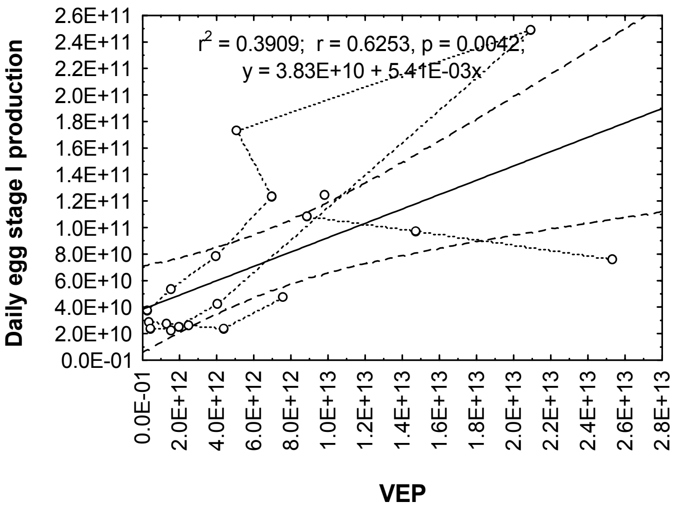


Fig. 1.5.11. The cod stage I egg production estimated from observed egg abundance in the Bornholm Basin as a linear function of a) the potential egg production (PEP), b) the egg production buoyant within the reproductive volume (RVEP), and c) the viable egg production (VEP). Dashed lines denotes the 95% confidence

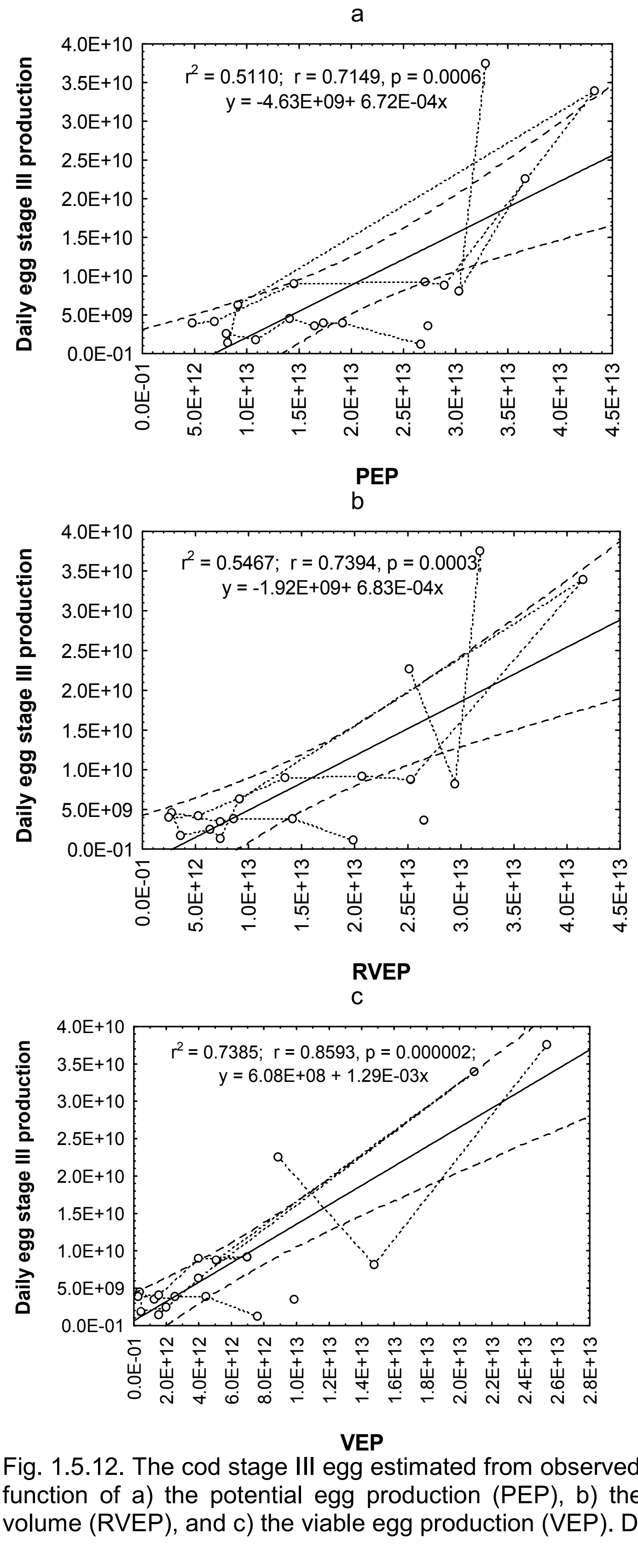


Fig. 1.5.12. The cod stage III egg estimated from observed egg abundance in the Bornholm Basin as a linear function of a) the potential egg production (PEP), b) the egg production buoyant within the reproductive volume (RVEP), and c) the viable egg production (VEP). Dashed lines denotes the 95% confidence limits.

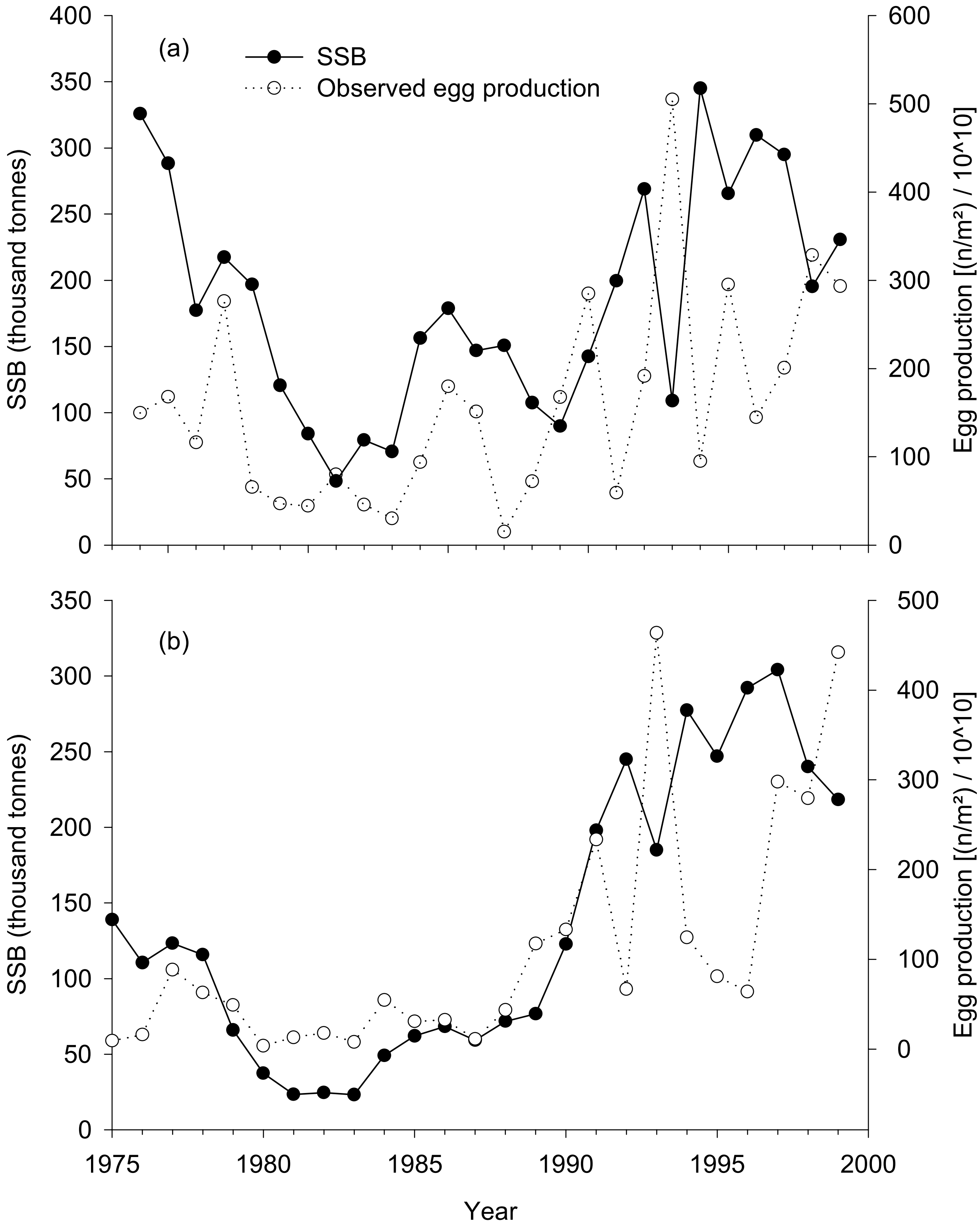


Fig. 1.5.13.Time series of sprat SSB and realised egg production as production of egg stage I in a) Sub-div. 26 and b) 28.

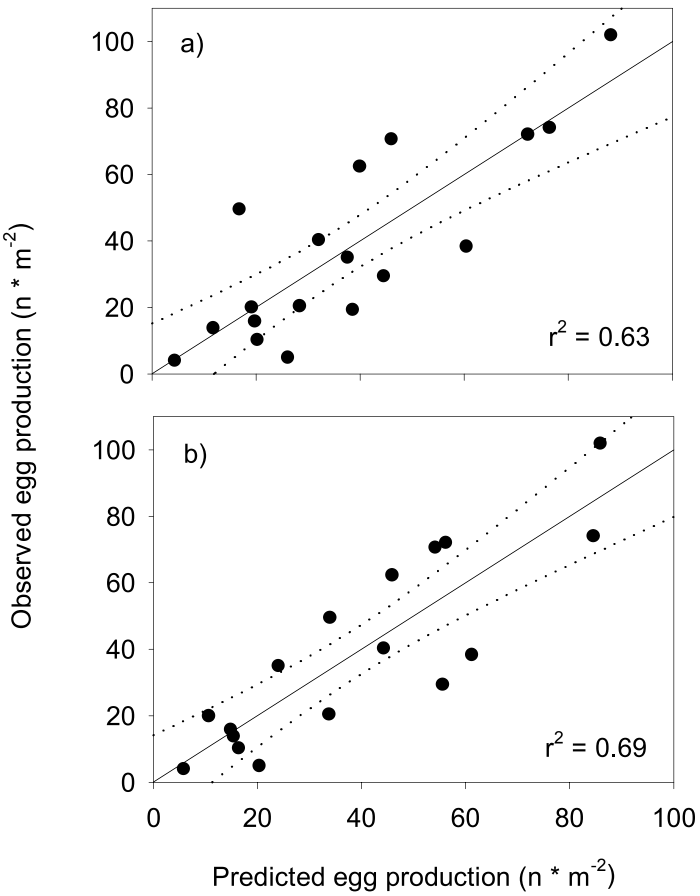


Fig. 1.5.14. Realized egg production of sprat in Sub-division 26 from ichthyoplankton surveys versus predicted by a multiple linear regression model utilizing SSB, weight at age anomaly in the 1st quarter (age-groups 2-4) and temperature in the intermediate water layer in May/June as independent variables (a), versus predicted by a multiple linear regression model utilizing SSB, growth anomaly (increase in weight at age 2-4 from 3rd to 2nd quarter) and temperature in the intermediate water in May/June as independent variables (b), with 95% confidence intervals.

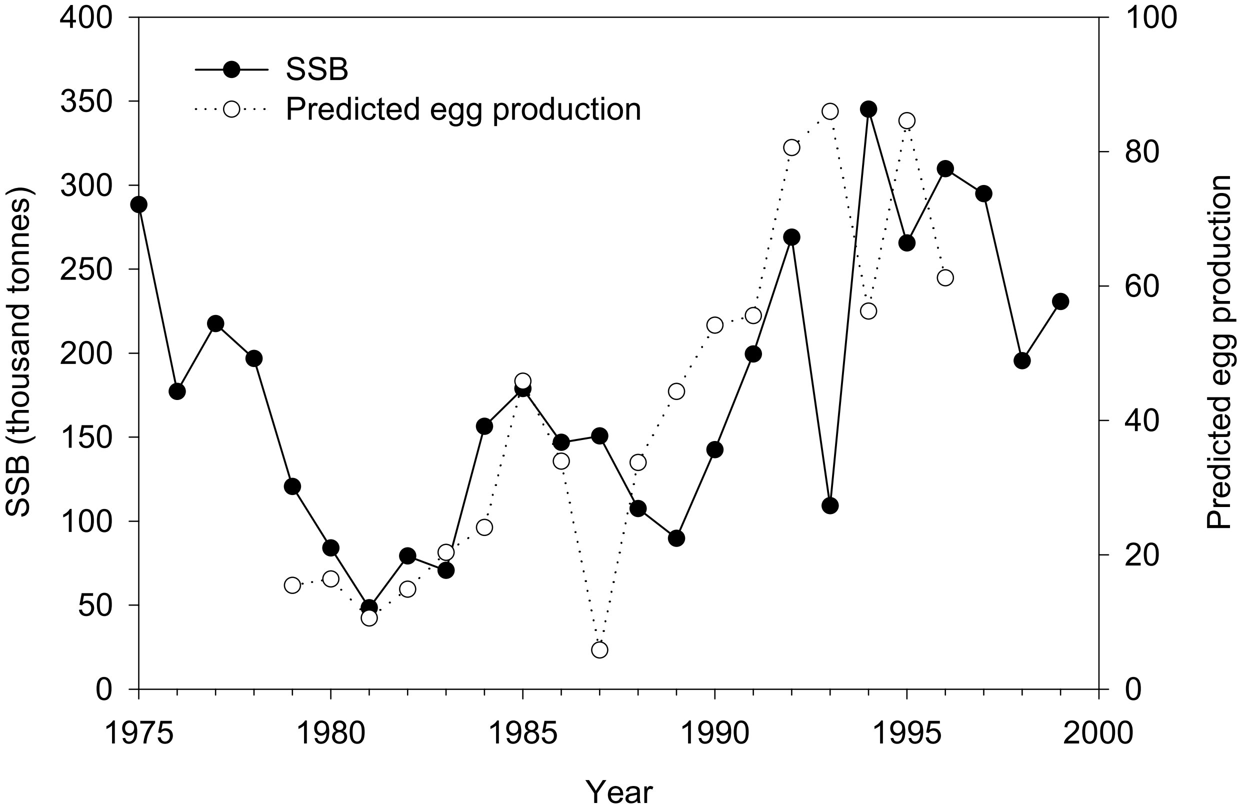


Fig. 1.5.15. Viable sprat egg production predicted by a multible regression model using SSB, ambient temperature and growth anomaly as wellas the comparable SSB of sprat in Sub-div. 26 over the year range used in the model.

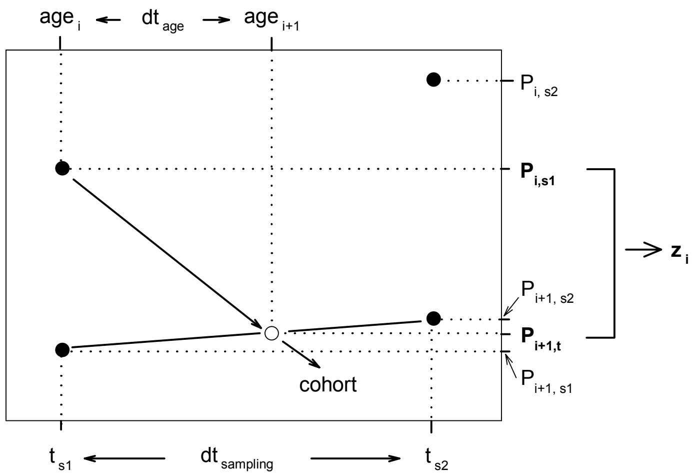


Fig. 2.1.1. Linear interpolation of number of eggs produced per day by developmental stage between two sampling dates (t: time, s: series of samples, P: daily production, z: instantaneous mortality coefficient, i: index of developmental stage).

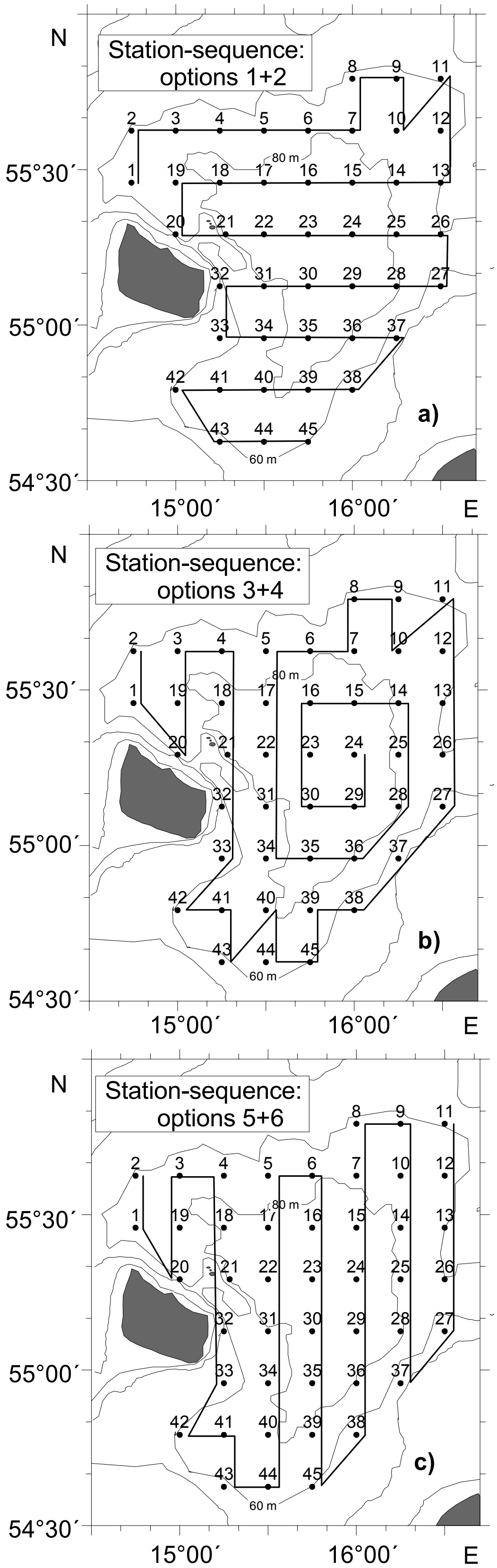


Fig. 2.1.2. Tested options for the influence of the station sequence: (a) options 1 (station1-45) and 2 (45-1); (b) options 3 (2-11) and 4 (11-2); (c) options 5 (2-24) and 6 (24-2); cruise tracks with the numbers and dots indicating the sampling positions of the 45 stations grid.

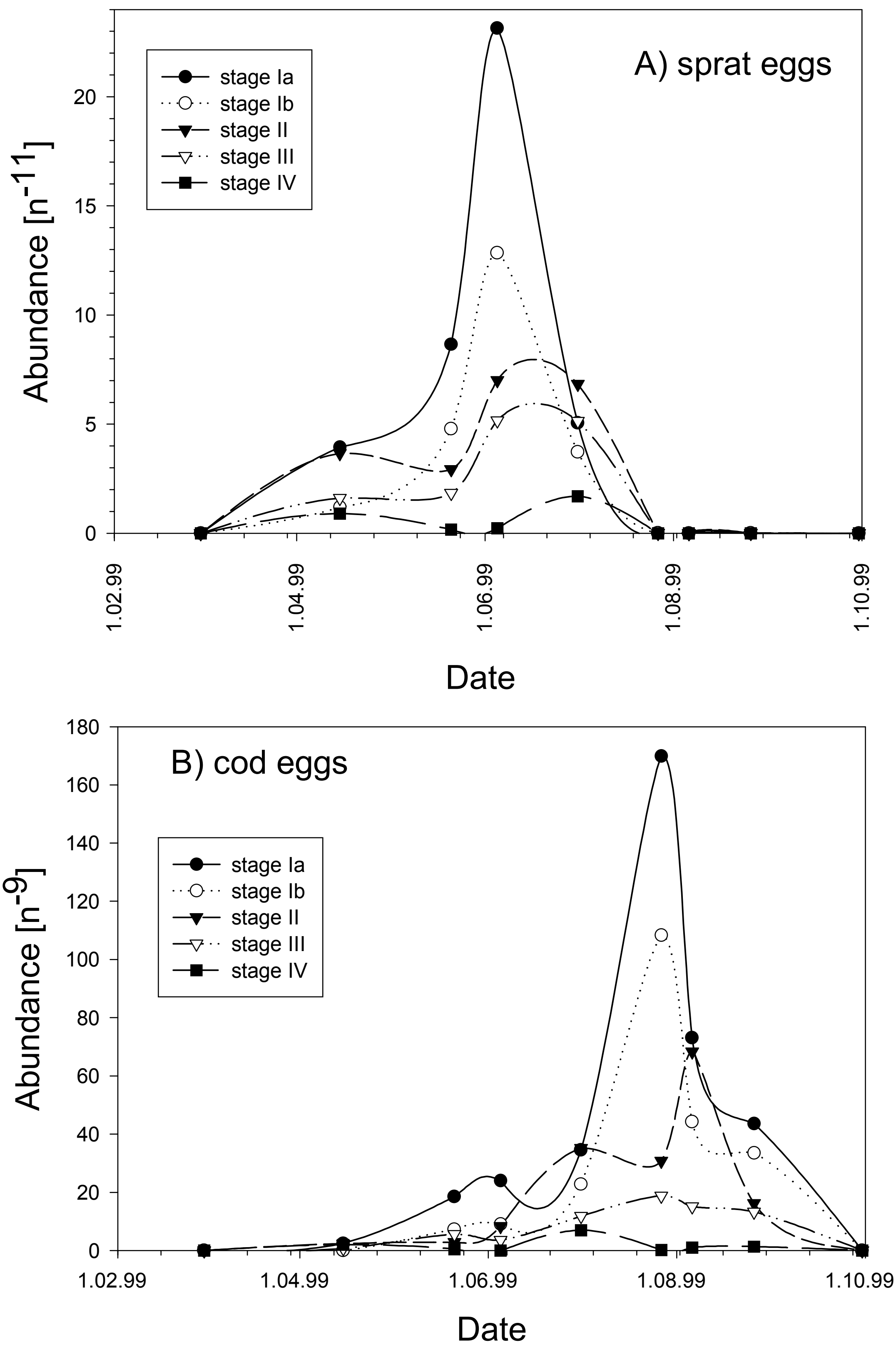


Figure 2.1.3. Calculated basin-wide abundance of different egg stages during the spawning season of 1999 for a) sprat eggs and b) cod eggs.

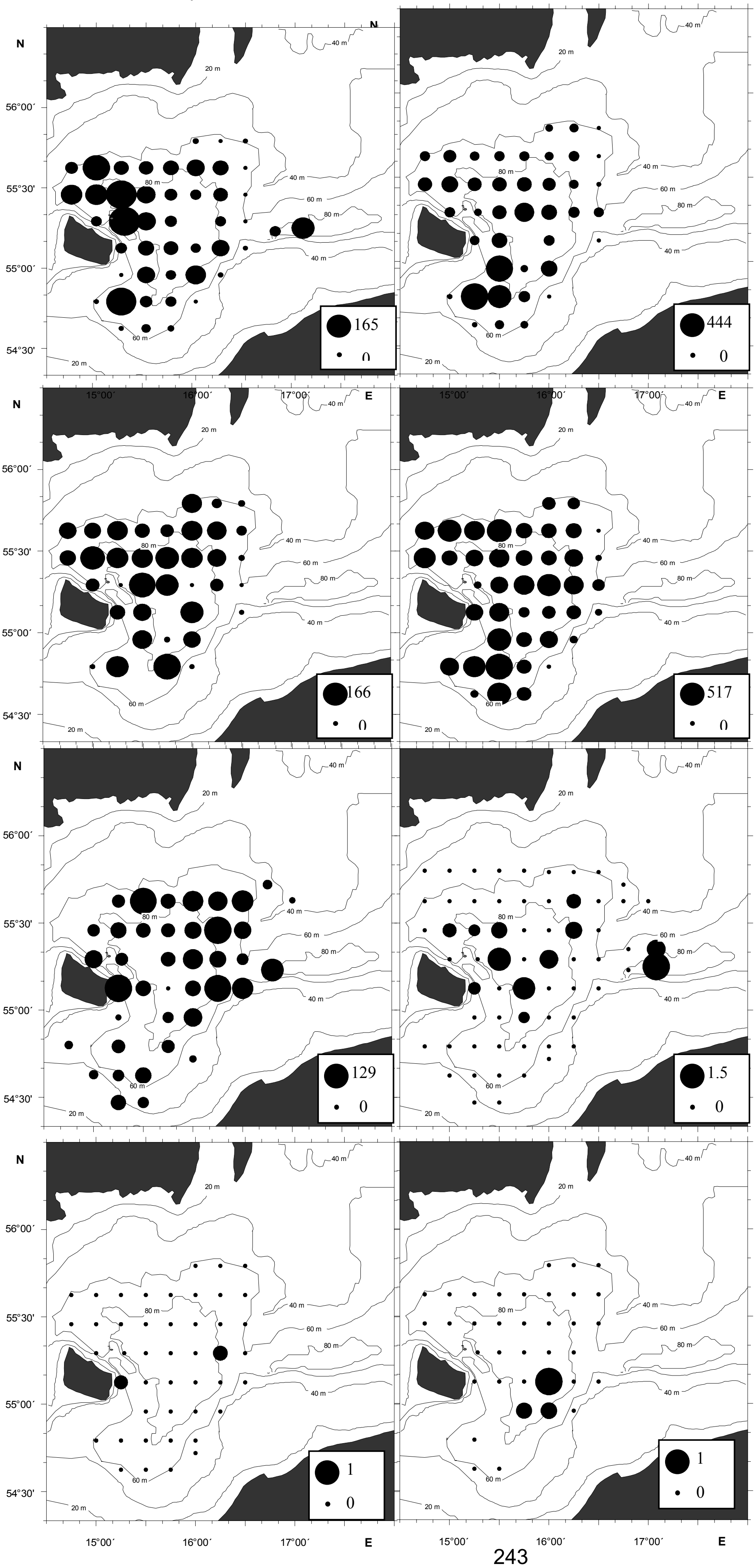


Fig. 2.1.4. Horizontal distribution of sprat egg-stage IA for the different sampling occasions in 1999.
up left (AL 141) to
down right (AL 148.

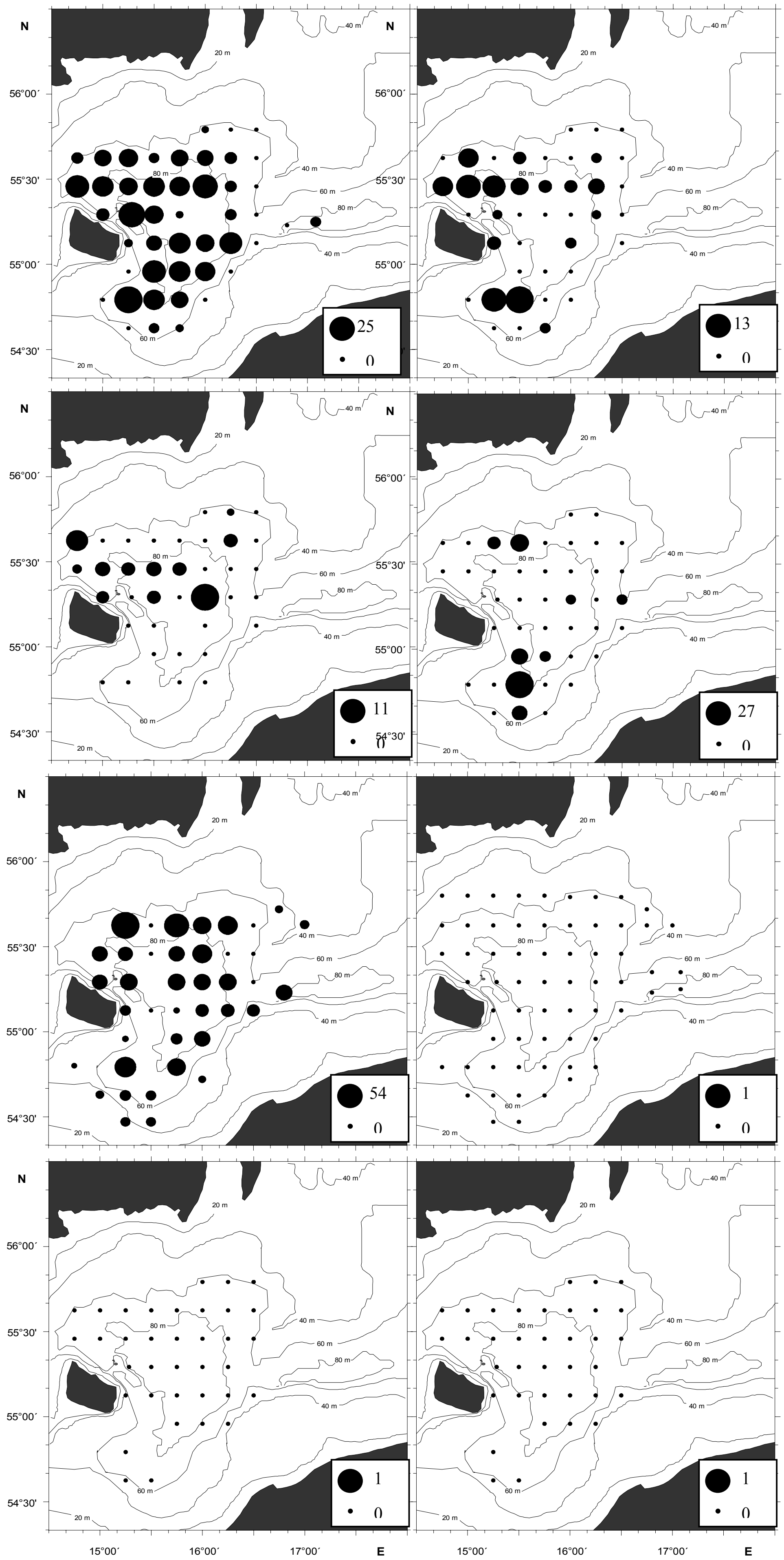


Fig. 2.1.5. Horizontal distribution of sprat egg-stage IV for the different sampling occasions in 1999.
up left (AL 141) to down right (AL 148.

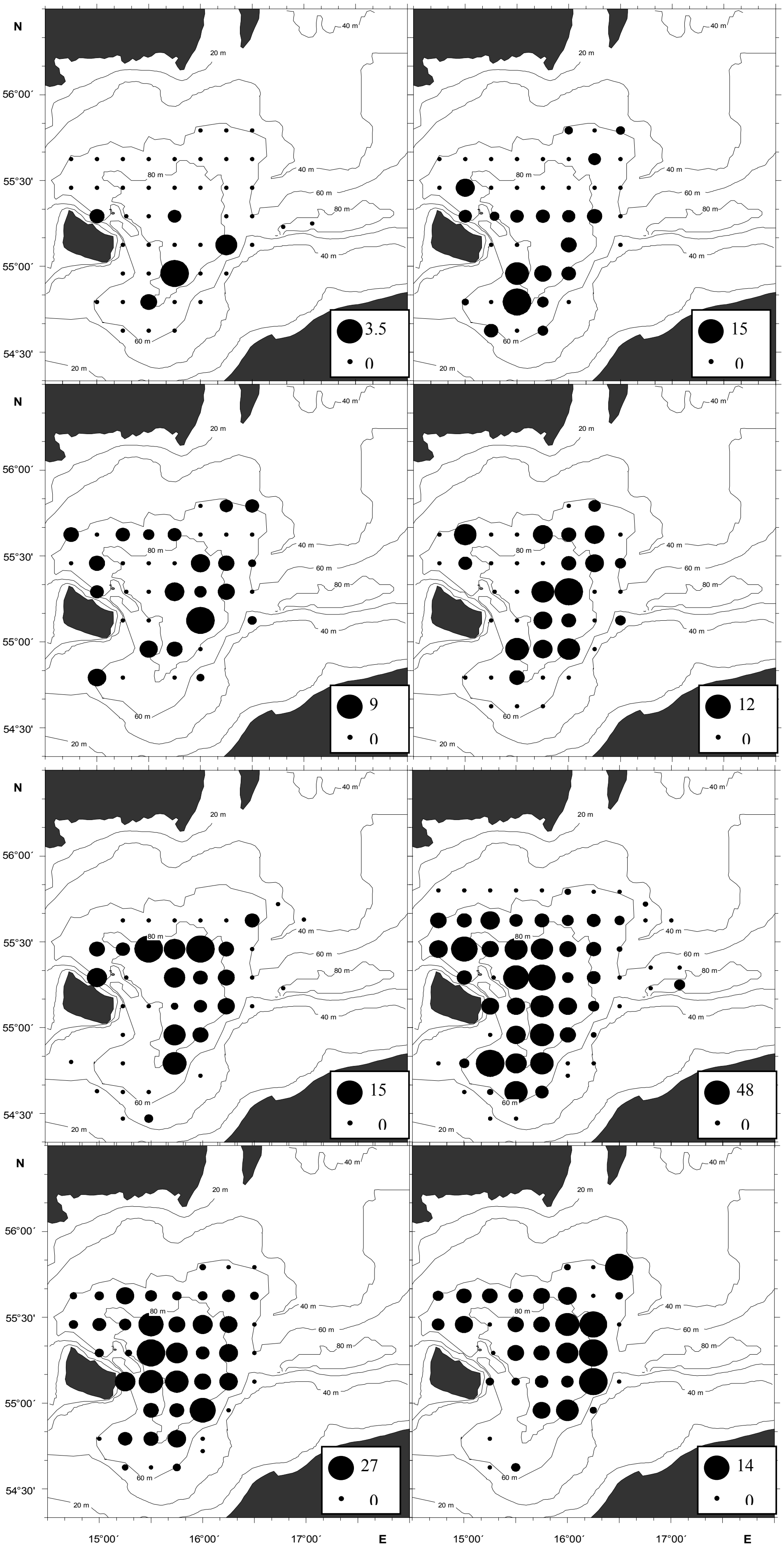


Fig. 2.1.6. Horizontal distribution of cod egg-stage IA for the different sampling occasions in 1999.
up left (AL 141) to down right (AL 148.

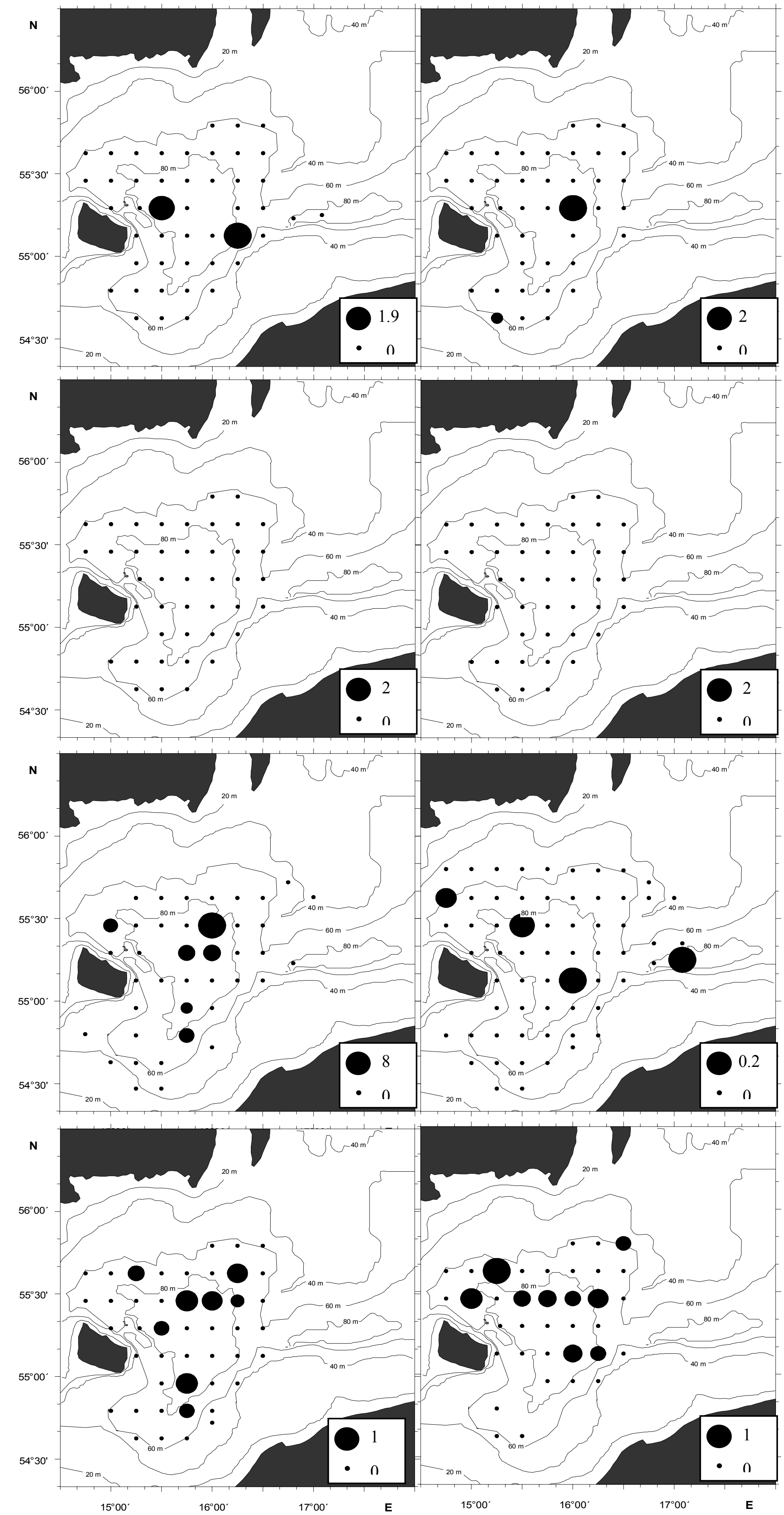


Fig. 2.1.7. Horizontal distribution of cod egg-stage IV for the different sampling occasions in 1999.
up left (AL 141) to
down right (AL 148.

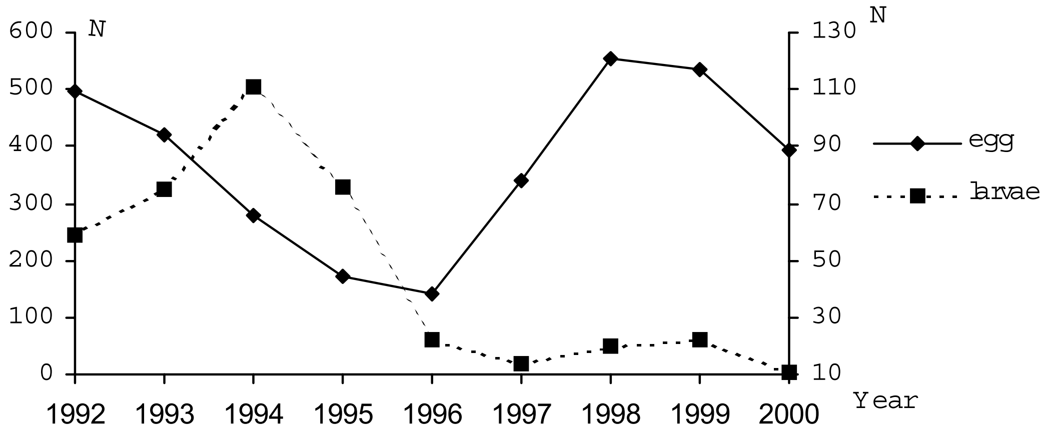


Fig. 2.1.8. The smoothed time series of sprat egg and small larvae abundance (sp/m^2) in the Gdansk Deep (May, early June 1992-2000).

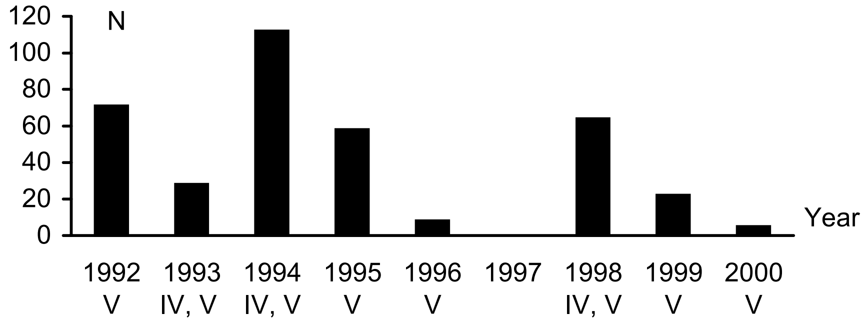


Fig. 2.1.9. Larvae sprat abundance (sp/m^2) in the Gdansk Deep in April-May.

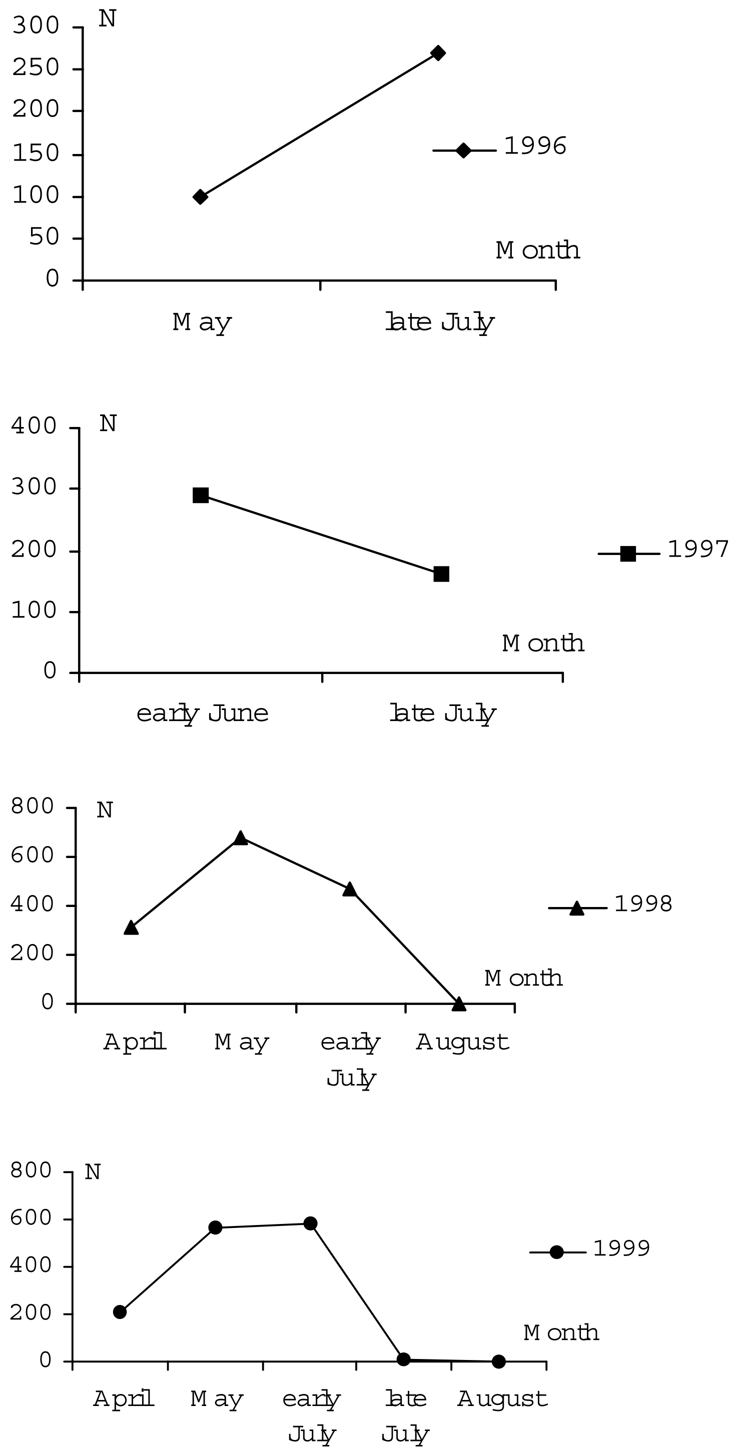


Fig 2.1.10. Seasonal variability of sprat egg abundance (sp/m2) in the Gdansk Deep in 1996-1999.

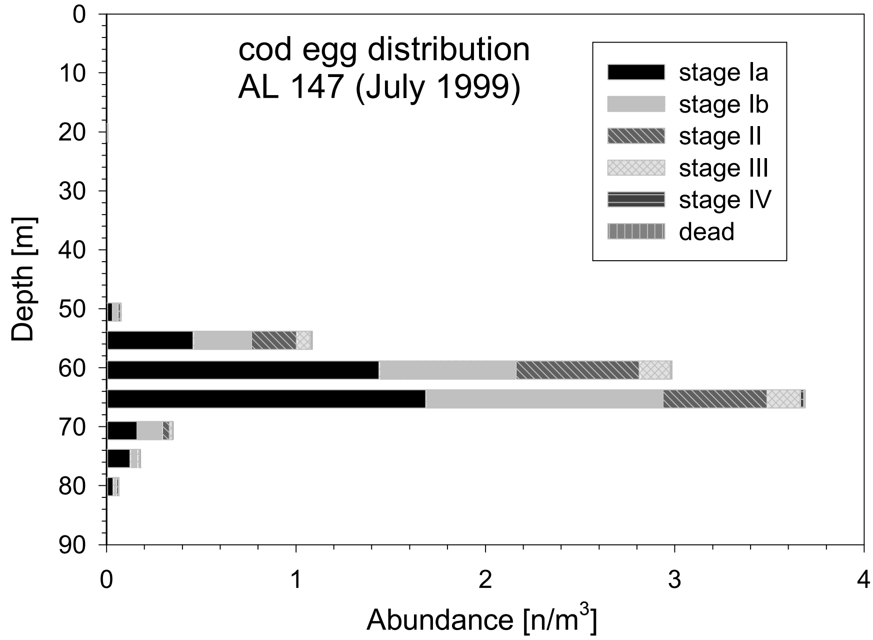


Fig. 2.1.11. Vertical distribution of cod eggs in the Bornholm Basin in July 1999 (AL 147).

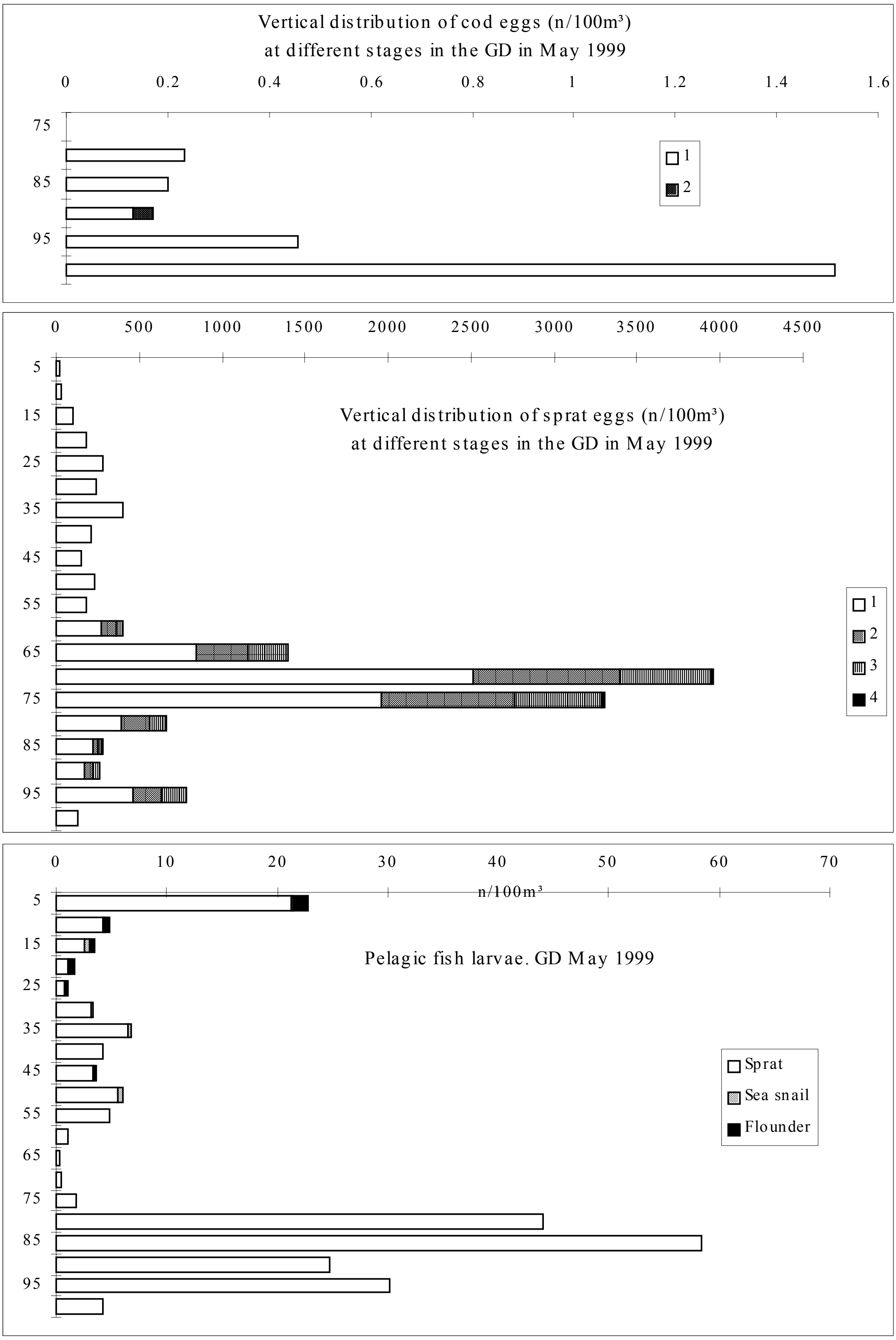


Fig. 2.1.12. Vertical distribution of pelagic fish eggs at different stages and larvae (n/100m^3) in the Gdansk Deep 29-30 May 1999.

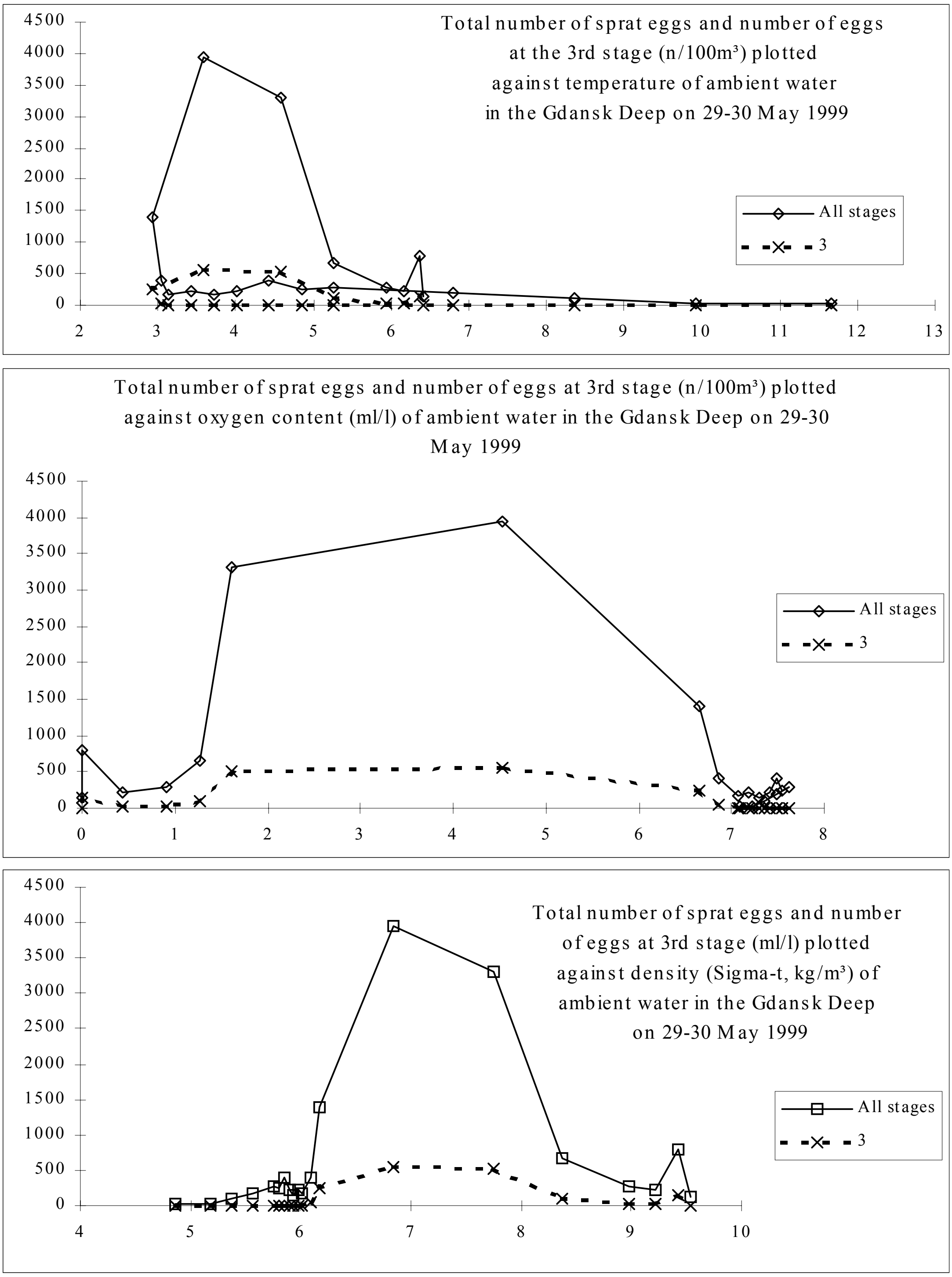


Fig. 2.1.13. Vertical distribution of sprat eggs in relation to hydrographic conditions in the Gdansk Deep.

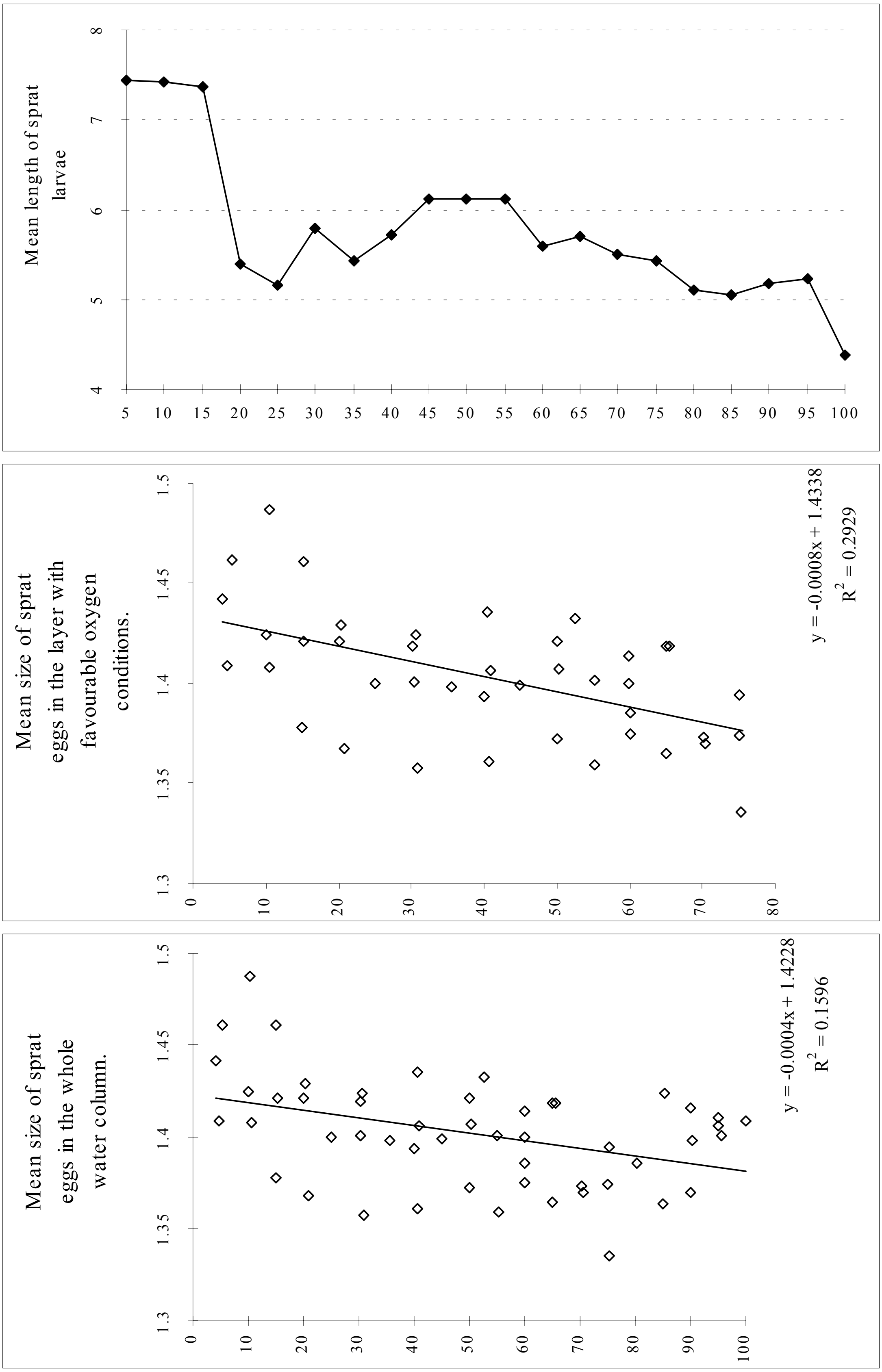


Fig. 2.1.14. Size of sprat eggs and larvae in relation to depth in the Gdansk Deep in May 1999.

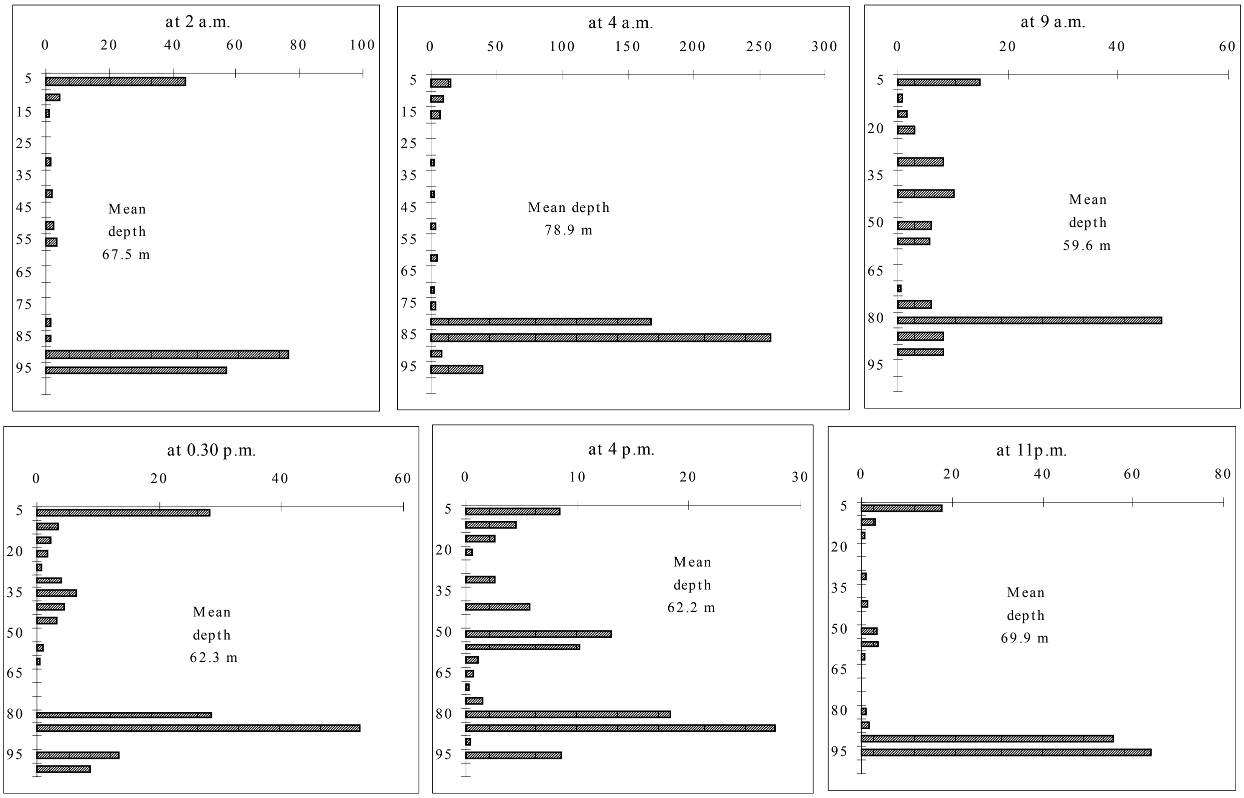


Fig. 2.1.15. Vertical distribution of sprat larvae (n/m^3) at different times of the day in May 1999, Gdansk Deep.

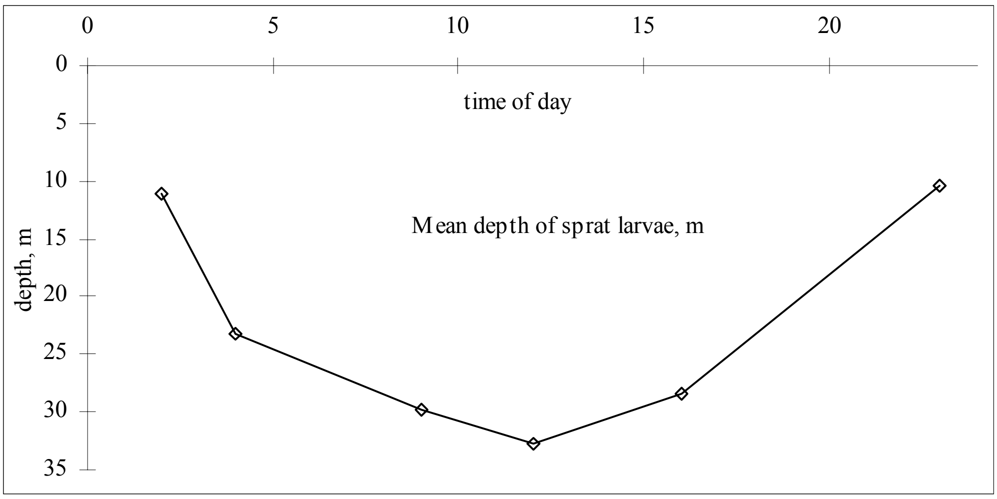


Fig. 2.1.16. Changes in the mean depth of sprat larvae in May 1999, Gdansk Deep. Depth >75m were excluded.

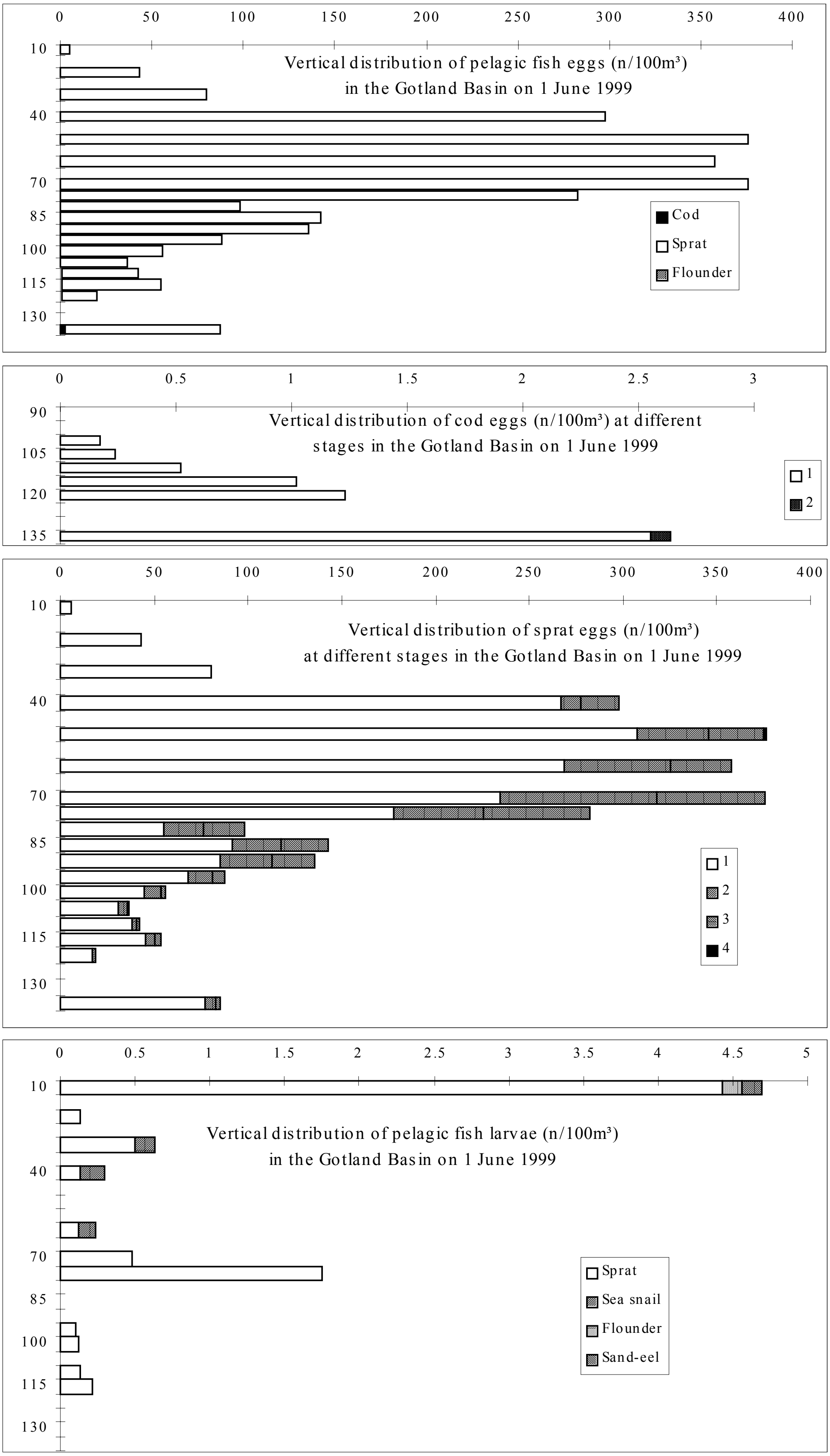
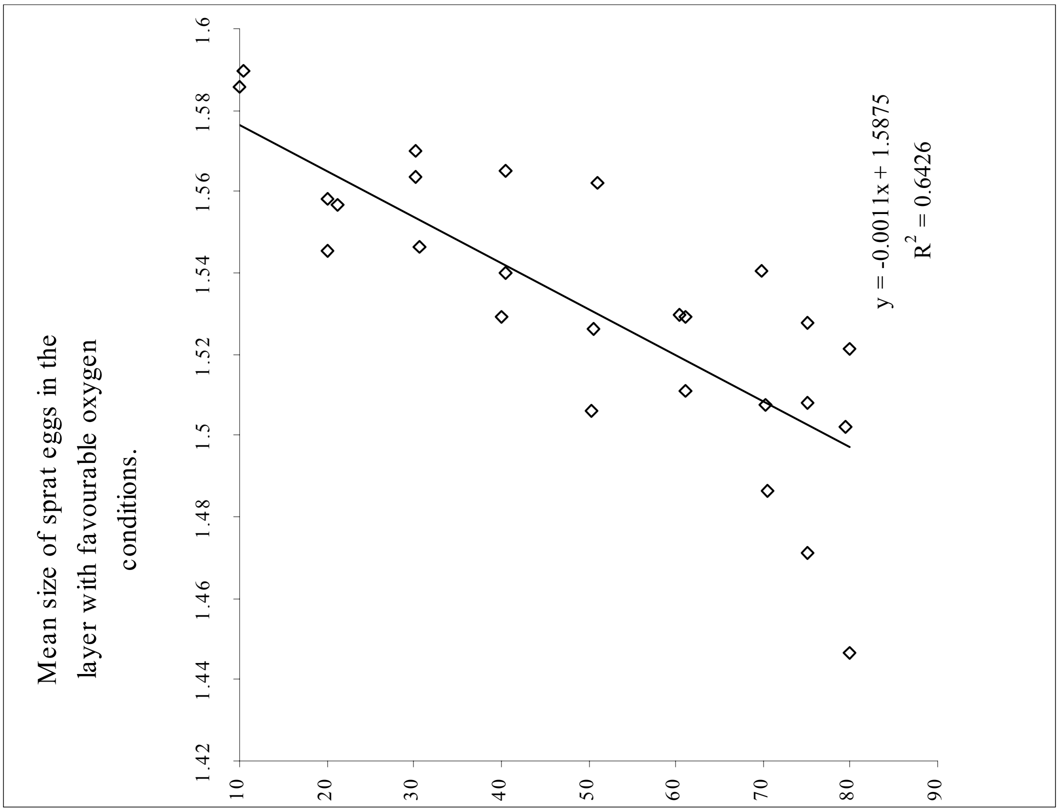


Fig. 2.1.17. Vertical distribution of pelagic fish eggs and larvae in the Gotland Basin. 1st June 1999.



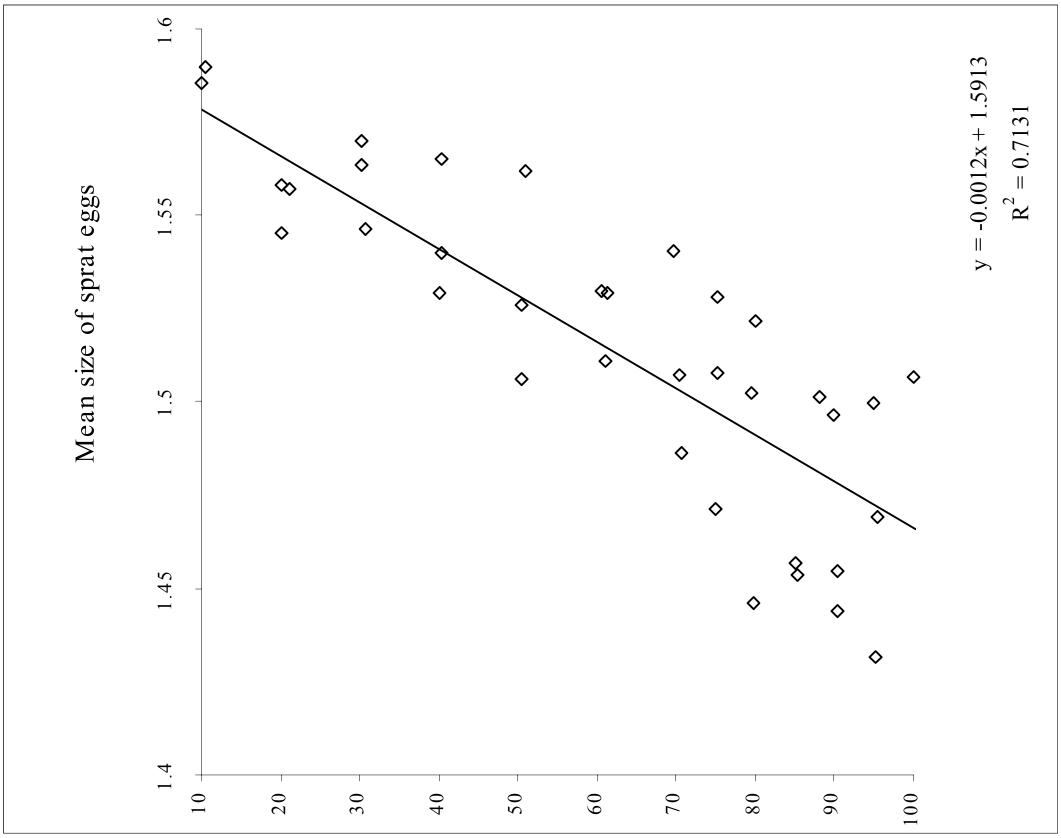


Fig. 2.1.18. Changes in the size of sprat eggs (diameter, mm) with depth in June 1999, Gotland Basin.

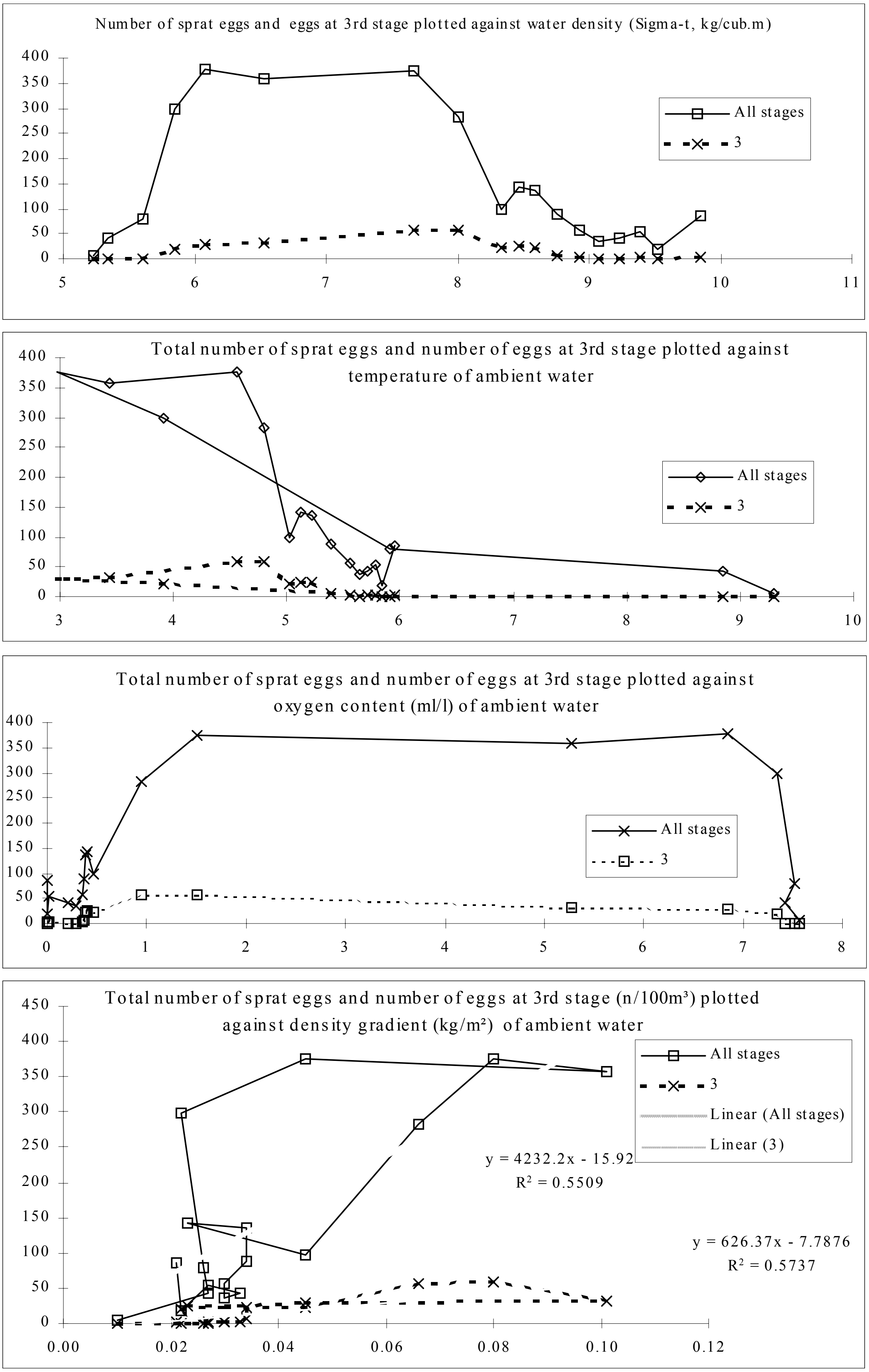


Fig. 2.1.19. Vertical distribution of sprat eggs (all stages, 3[rd] stage) in relation to the hydrographic conditions in June 1999, Gotland Basin.

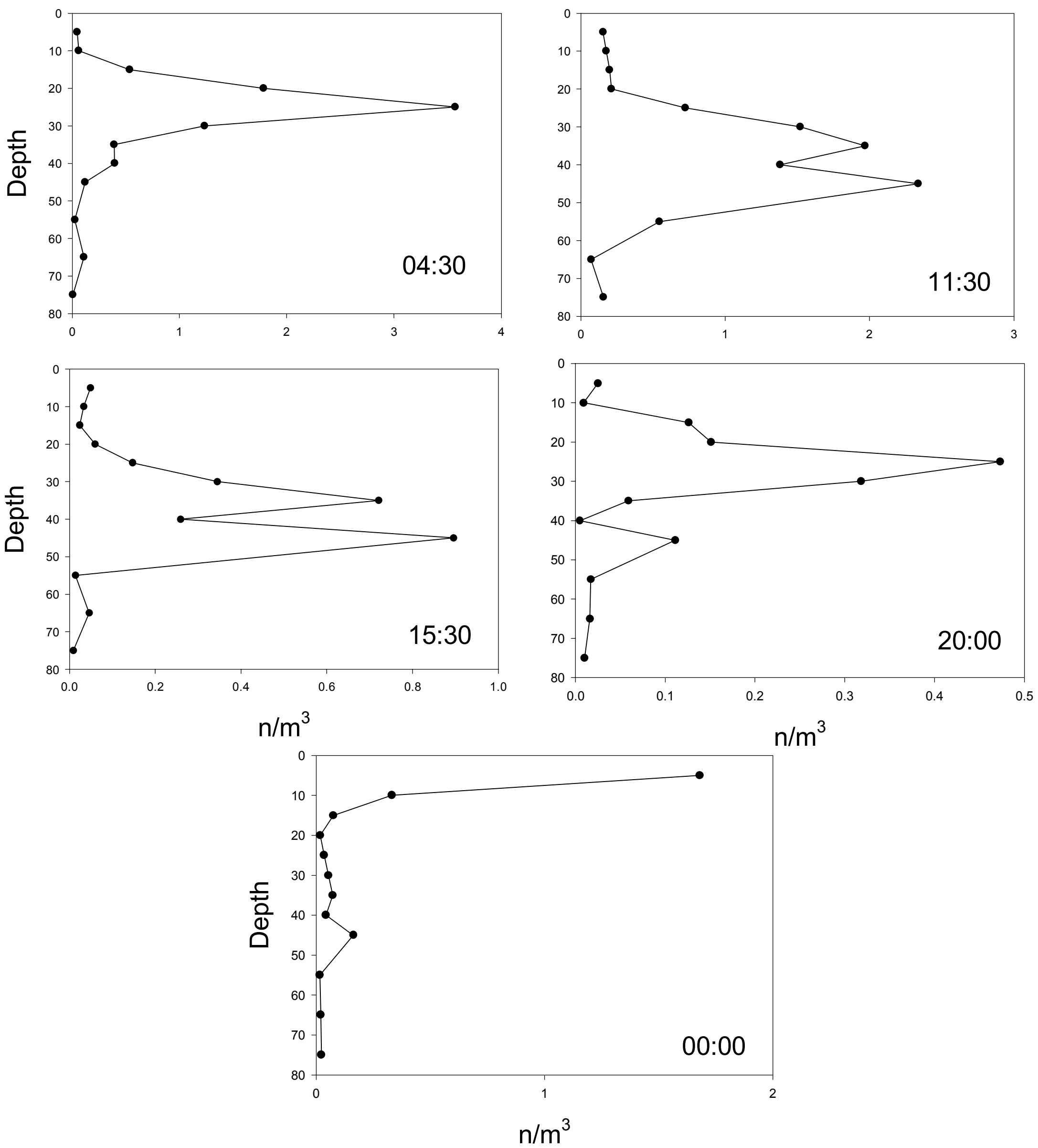


Figure 2.1.20 Vertical distribution of sprat larvae at 5 different times of the day in May 1989.

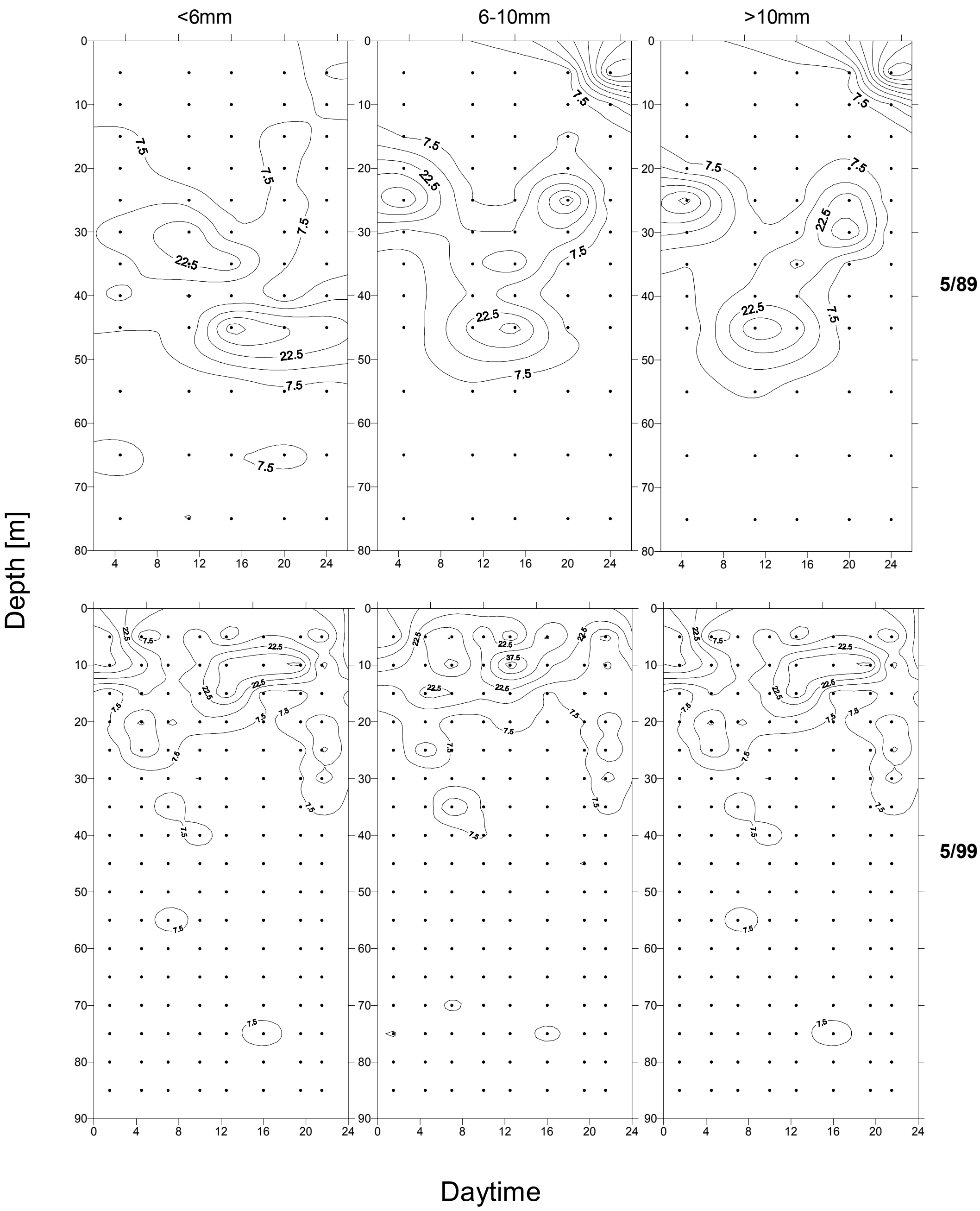


Figure 2.1.21. Time-dependant vertical distribution of 3 size-classes of sprat larvae in May 1989 (upper panel) and May 1999 (lower panel). Lines are contours of relative abundance (% per depth stratum); dots indicate sampled times/depths.

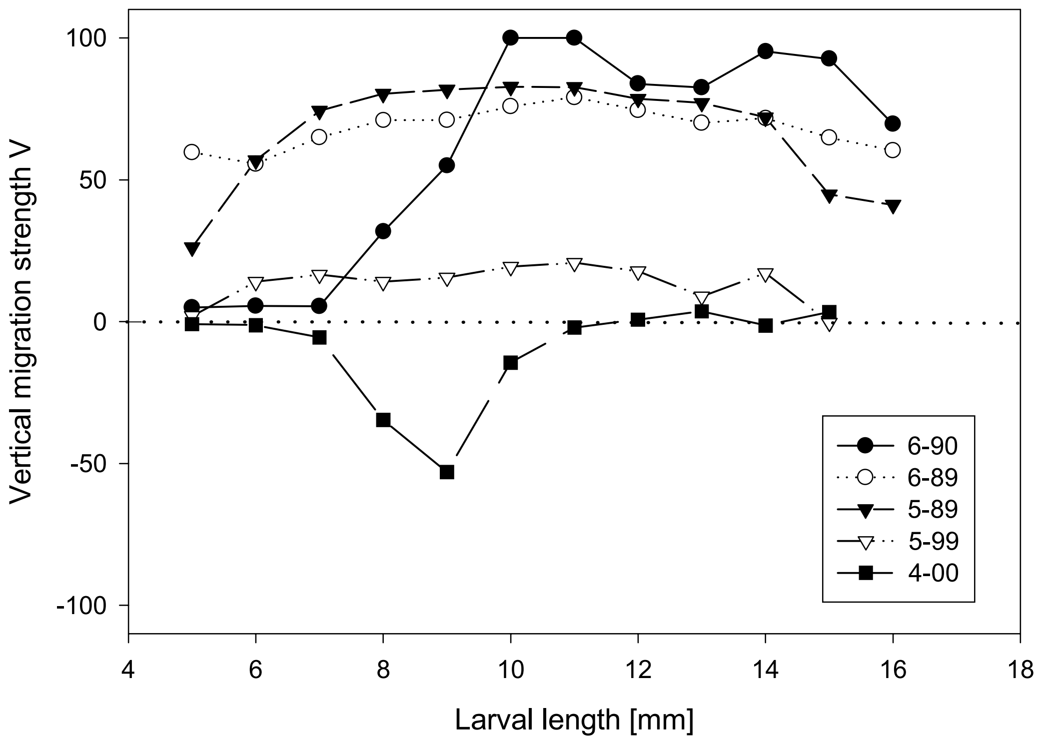


Figure 2.1.22. Vertical migration strength V (Bollens and Frost, 1989) for 1mm size classes of sprat larvae at different sampling dates.

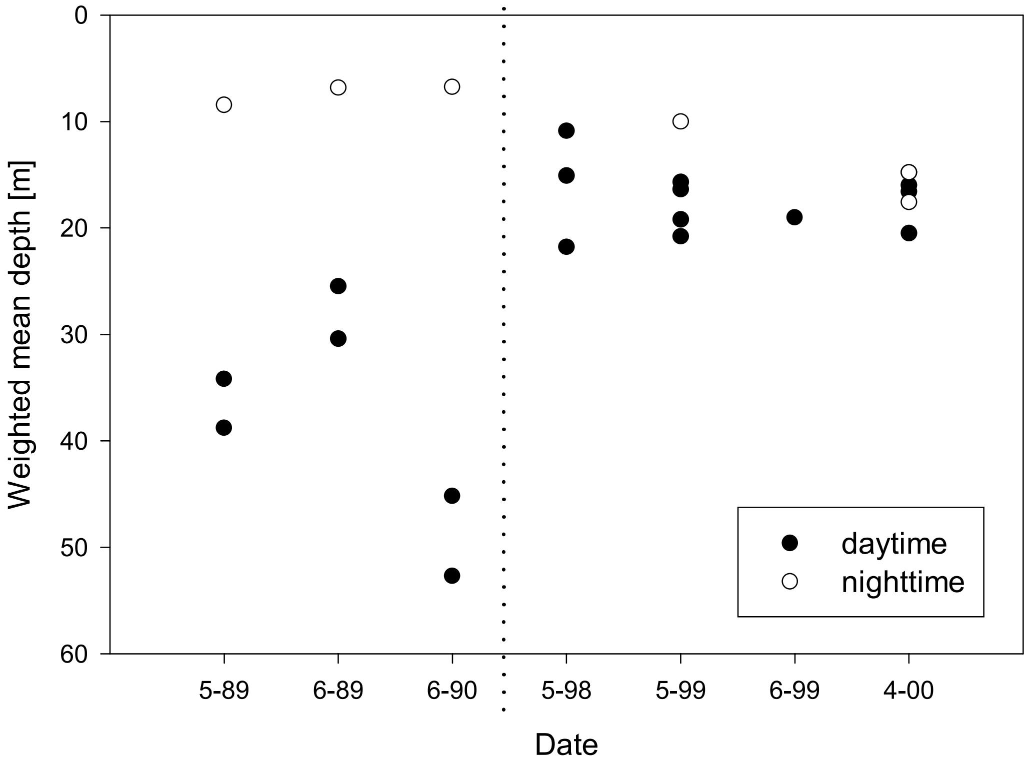


Figure 2.1.23. Weighted mean depths of sprat larvae >10mm from day-time samples (full circles; 1-4 replicates) and from night time samples (open circles; 1-2 replicates).

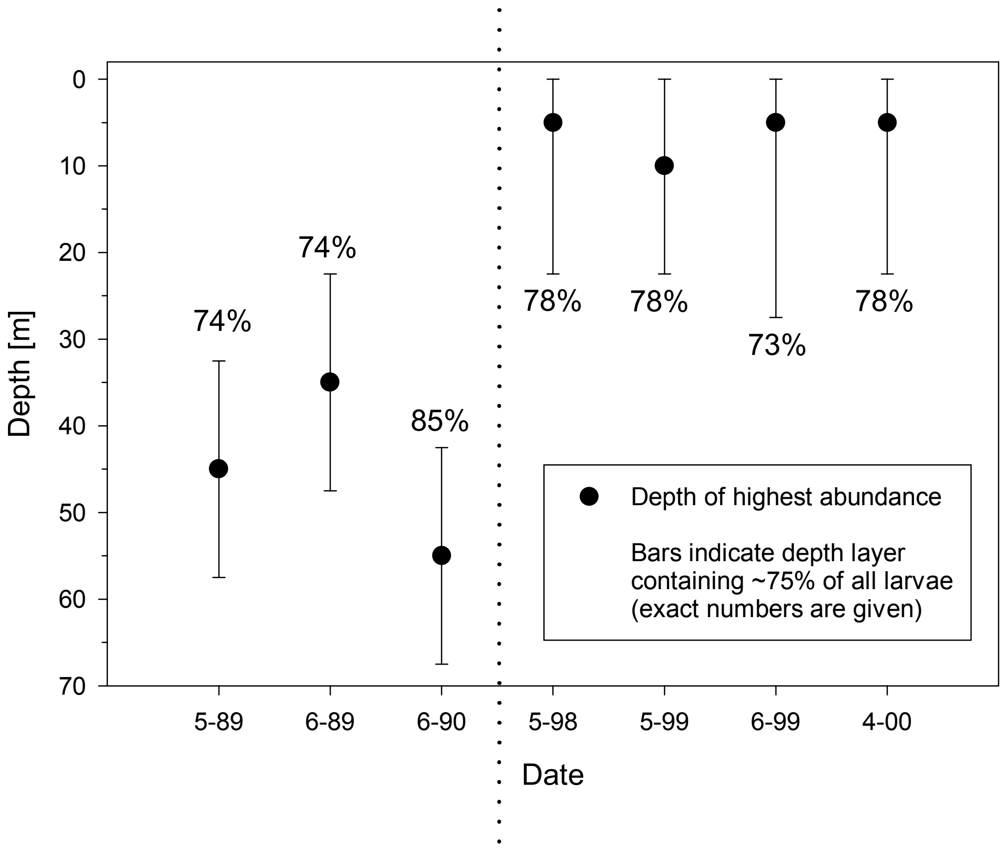


Figure 2.1.24. Depth of highest abundance of sprat larvae >10mm as well as depth layer containing the majority of larvae in this size class.

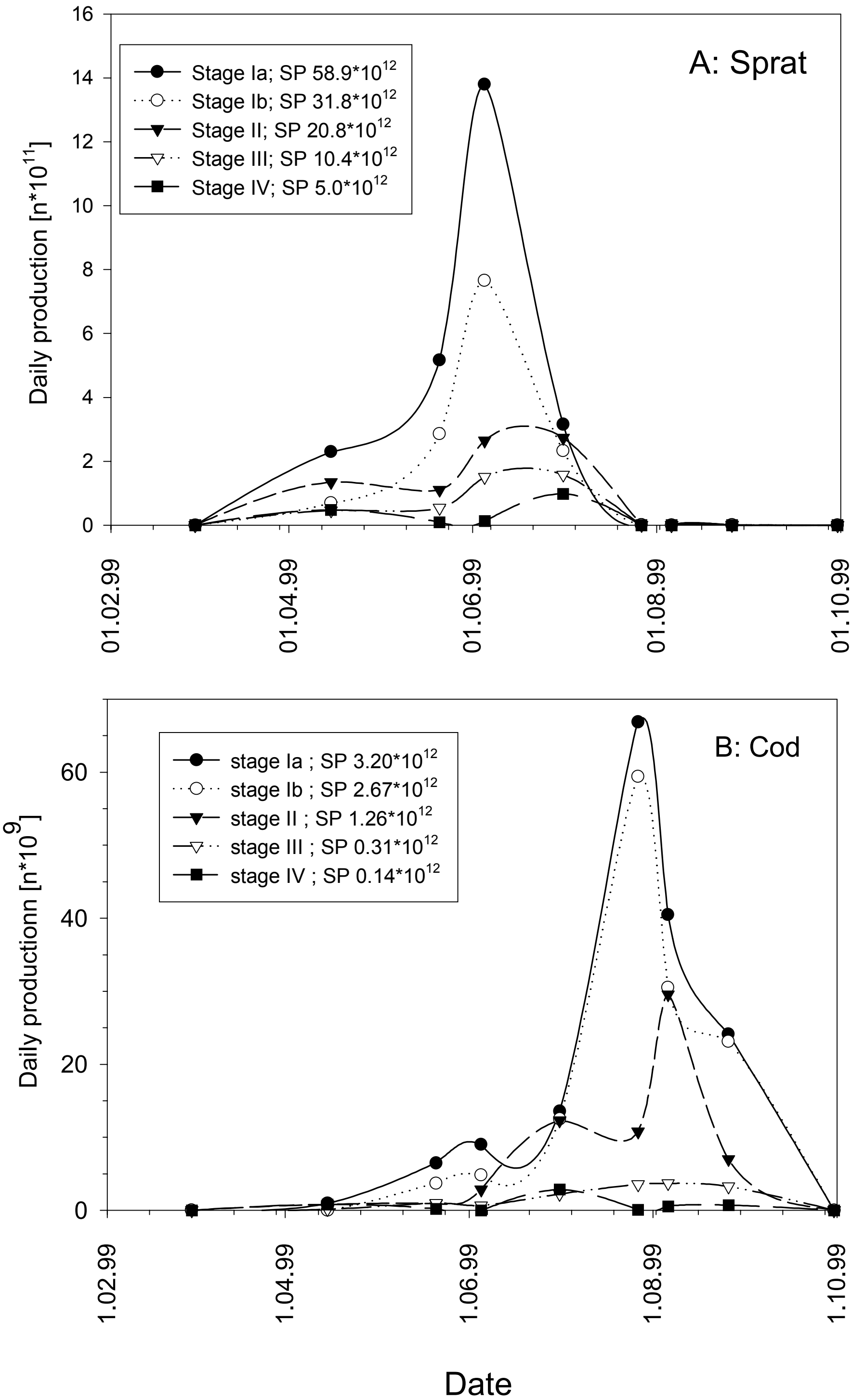


Fig. 2.1.25. Seasonal production curves of different egg-stages in the Bornholm Basin for a) sprat and b) cod.

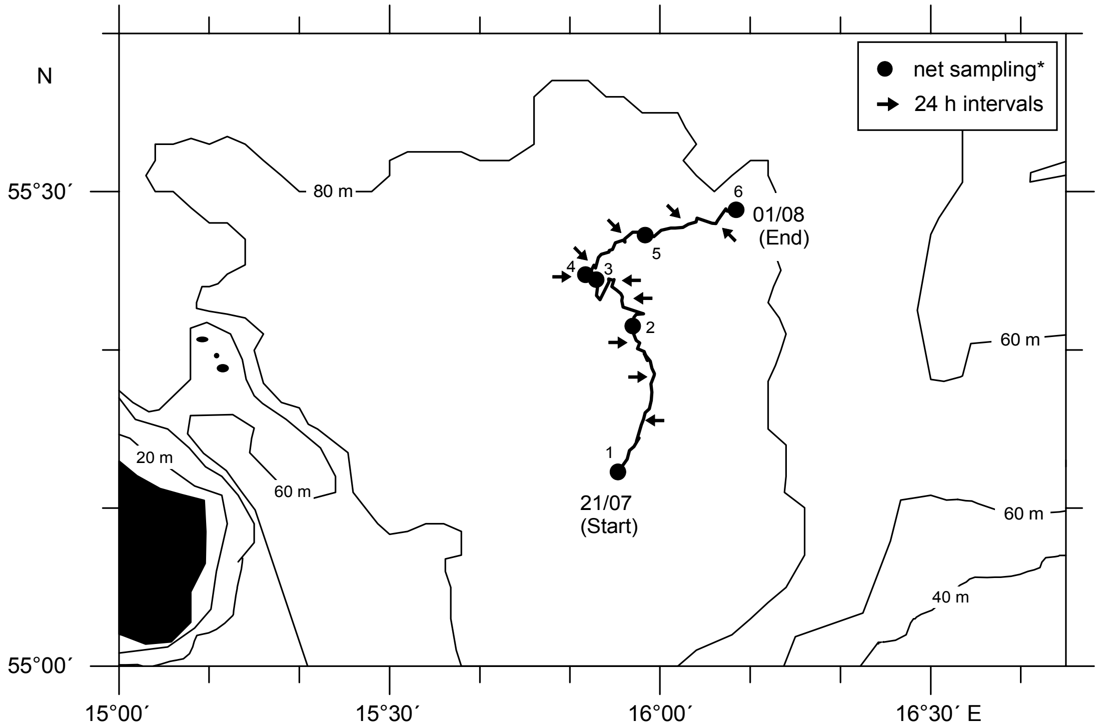


Fig. 2.1.26. Trajectory of the drifter and sampling locations (*: number denotes series of samples).

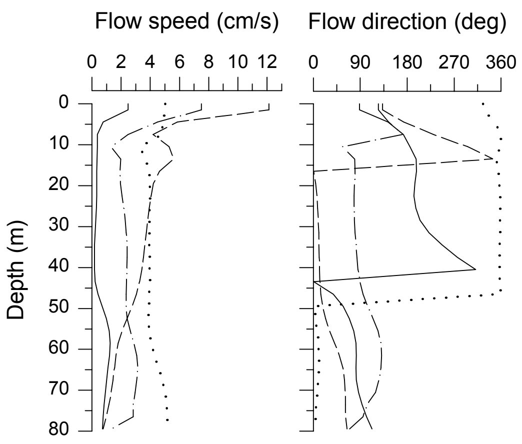


Fig. 2.1.27. Vertical profiles of daily mean flow speed and direction (model results) at the drifter position in 4 day intervals: 22.7. (solid line), 25.7. (dotted line), 28.7. (dashed line) and 31.7. (dash-dot line).

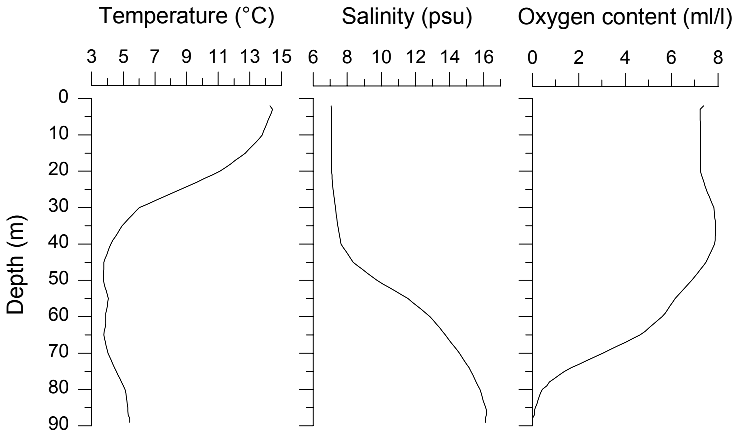


Fig. 2.1.28. . Mean hydrographic conditions recorded throughout the drift study.

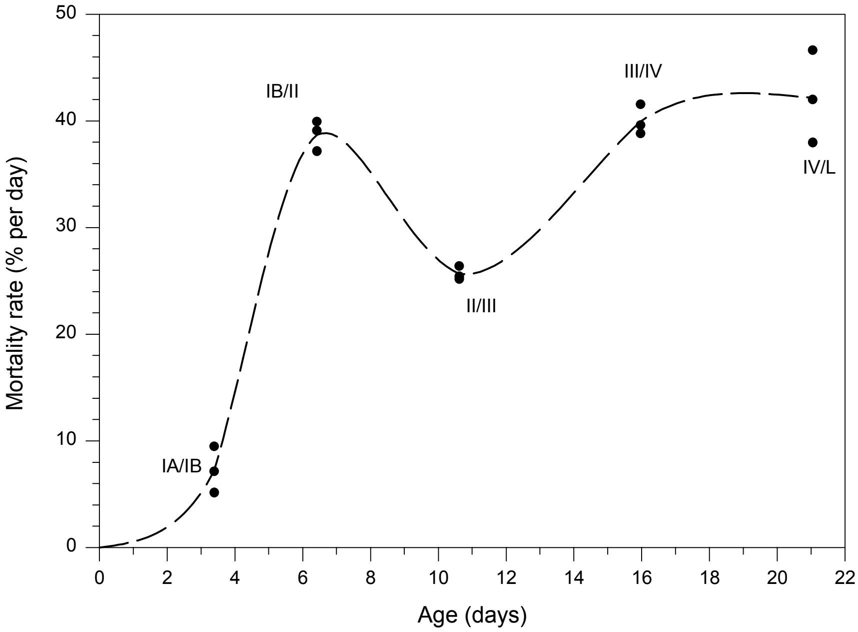


Fig. 2.1.29. Changes of daily mortality rates (Z) during development (dashed line: cubic spline fitted to mean values).

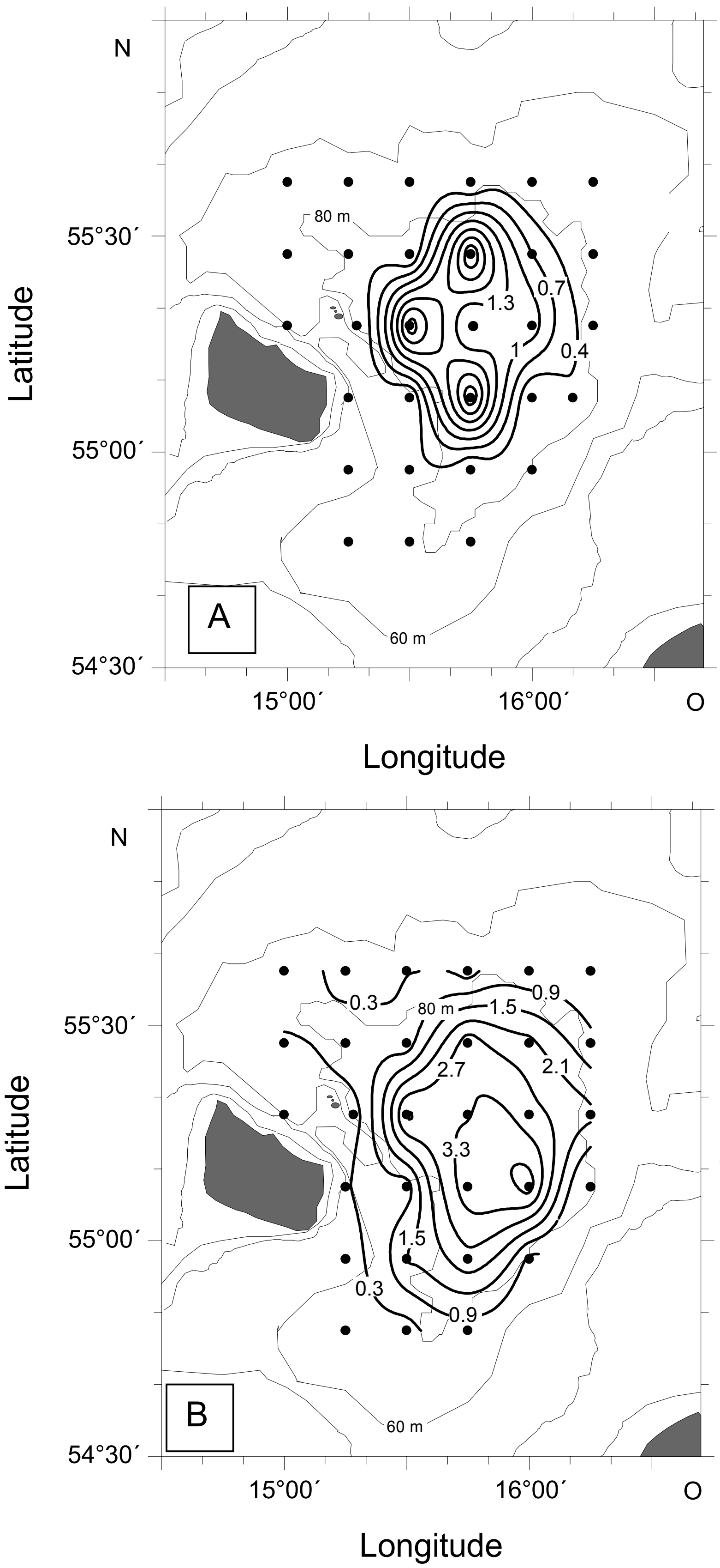
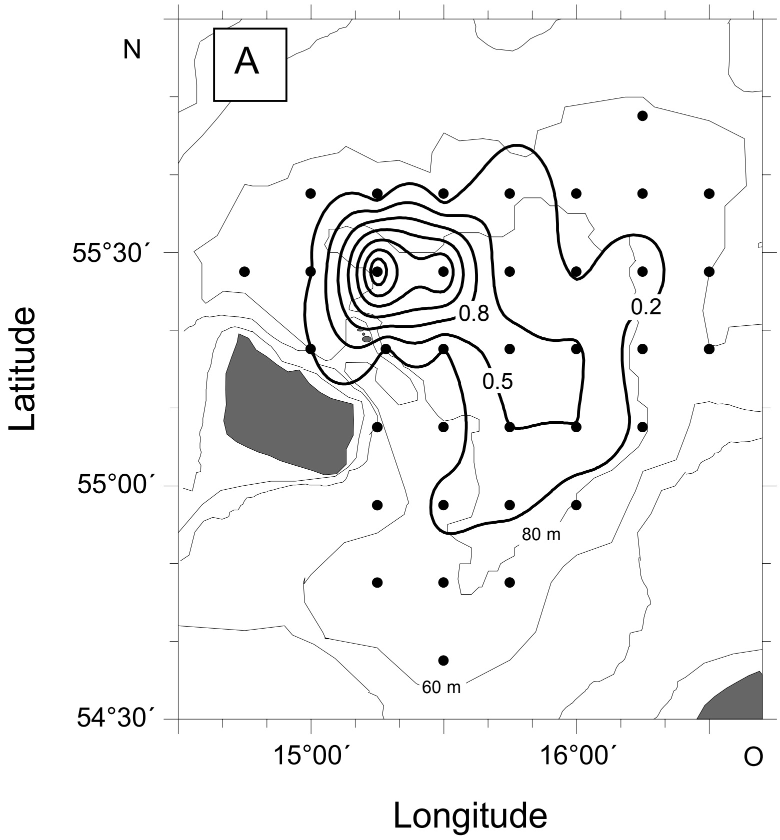


Fig. 2.1.30. May 1988, horizontal distribution of cod early life stages: a) first survey (19 May), cod egg stage IV; b) first survey (19 May), cod larval stages 5-7; contours of abundance are drawn as n/m² with dots indicating sampling positions.



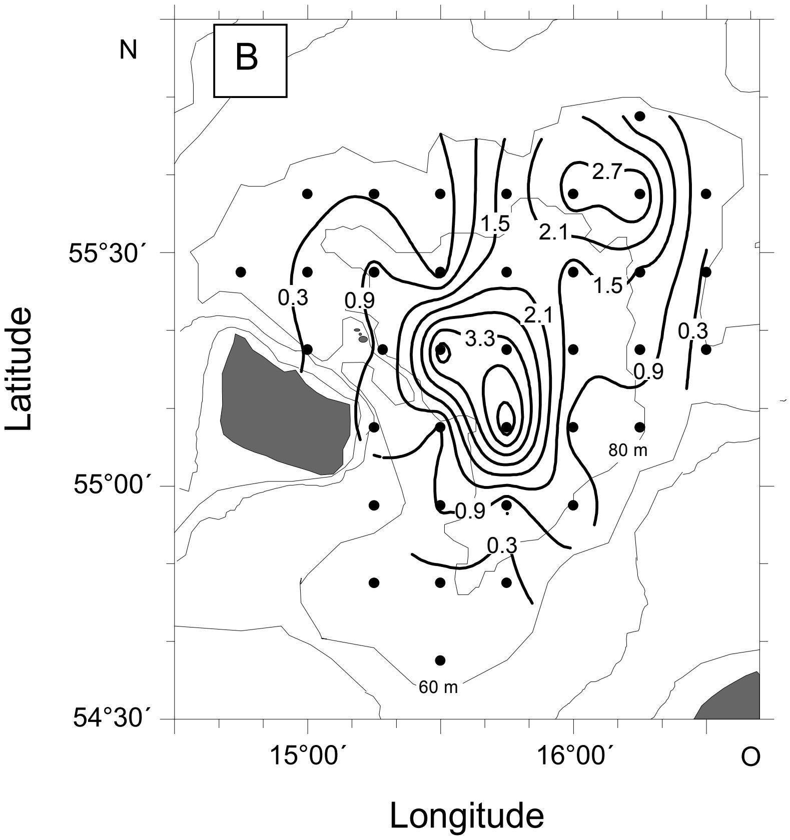


Fig. 2.1.31. August 1991, horizontal distribution of cod early life stages: a) first survey (11 August), cod egg stage IV; b) first survey (11 August), cod larval stages 5-7; contours of abundance are drawn as n/m² with dots indicating sampling positions.

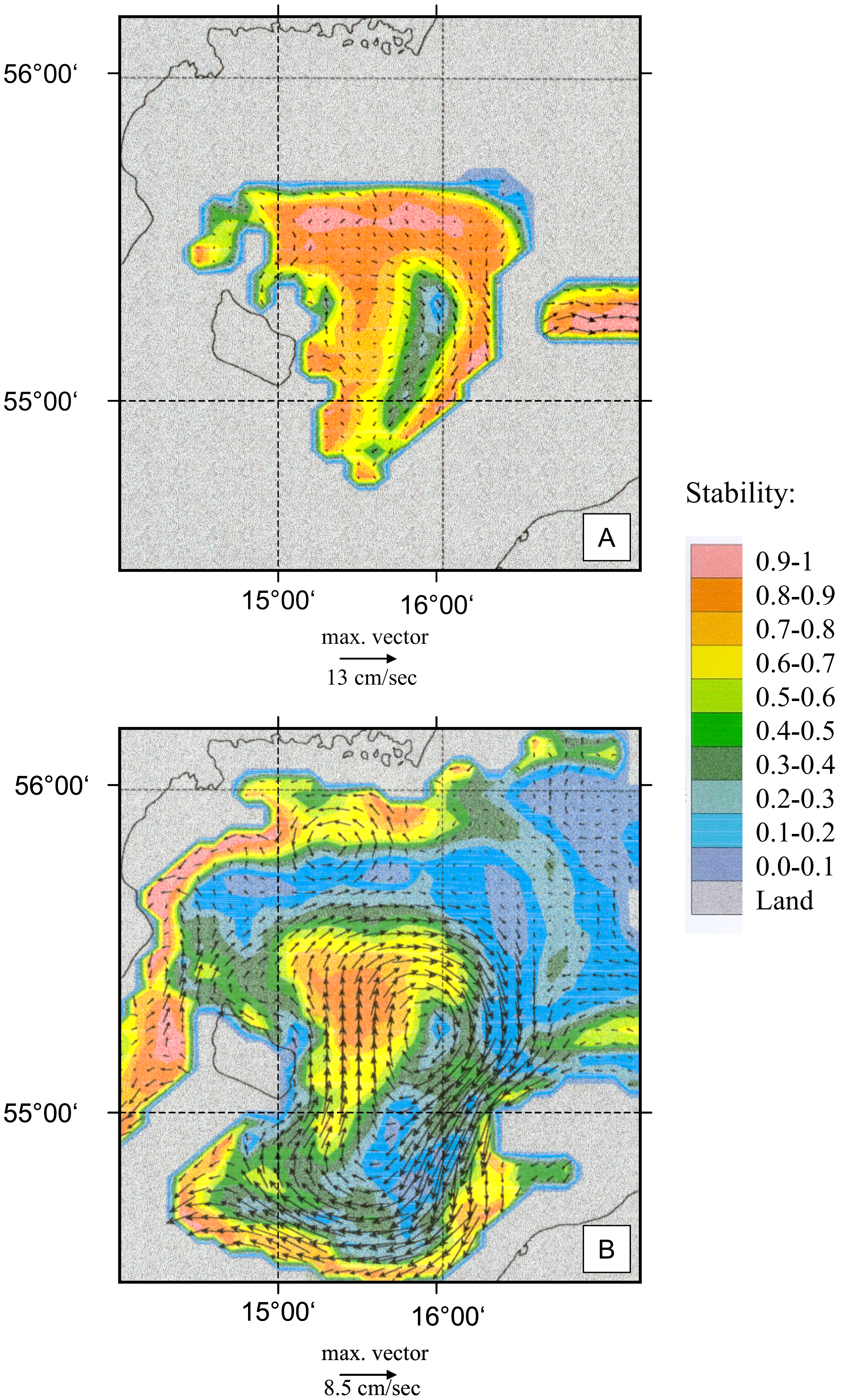


Fig. 2.1.32. Mean current fields and stability averaged over 5 days modelling time for 19-23 May 1988. a)depth layer 69-72m; b) depth layer 30-33m.

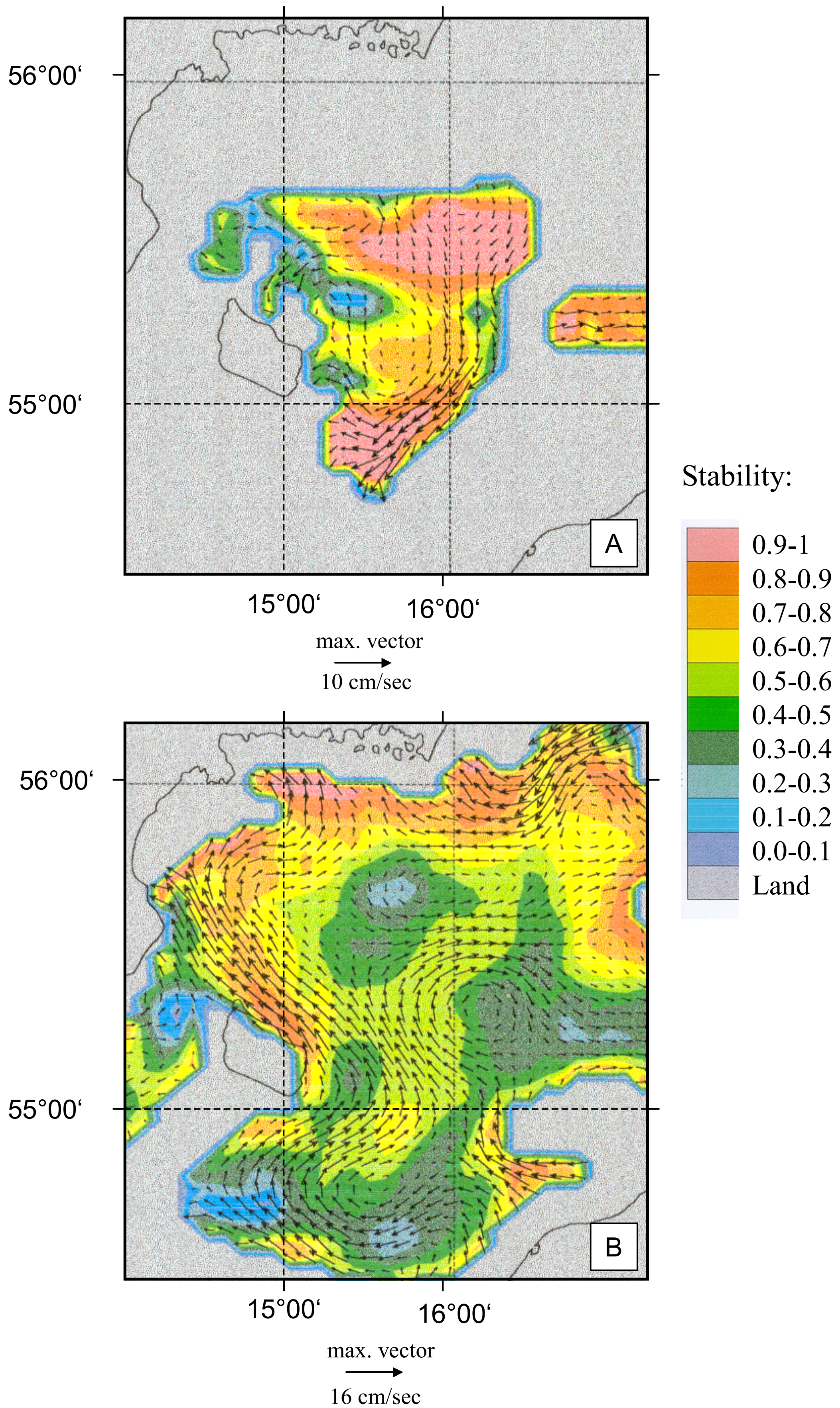


Fig. 2.1.33. Mean current fields and stability averaged over 5 days modelling time for 11-15 August 1991. a) depth layer 69-72m; b) depth layer 30-33m.

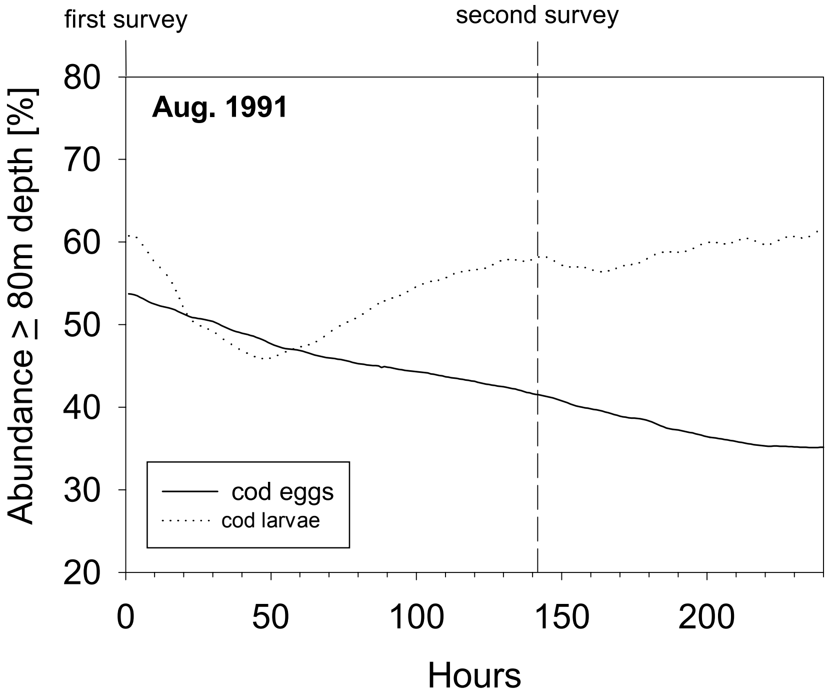


Fig. 2.1.34. Proportion of cod eggs and larvae distributed inside the 8om depth contour line. Temporal evolution due to transport processes in August 1991 (11-20 Aug.). Vertical lines indicate the temporal midpoint of sampling.

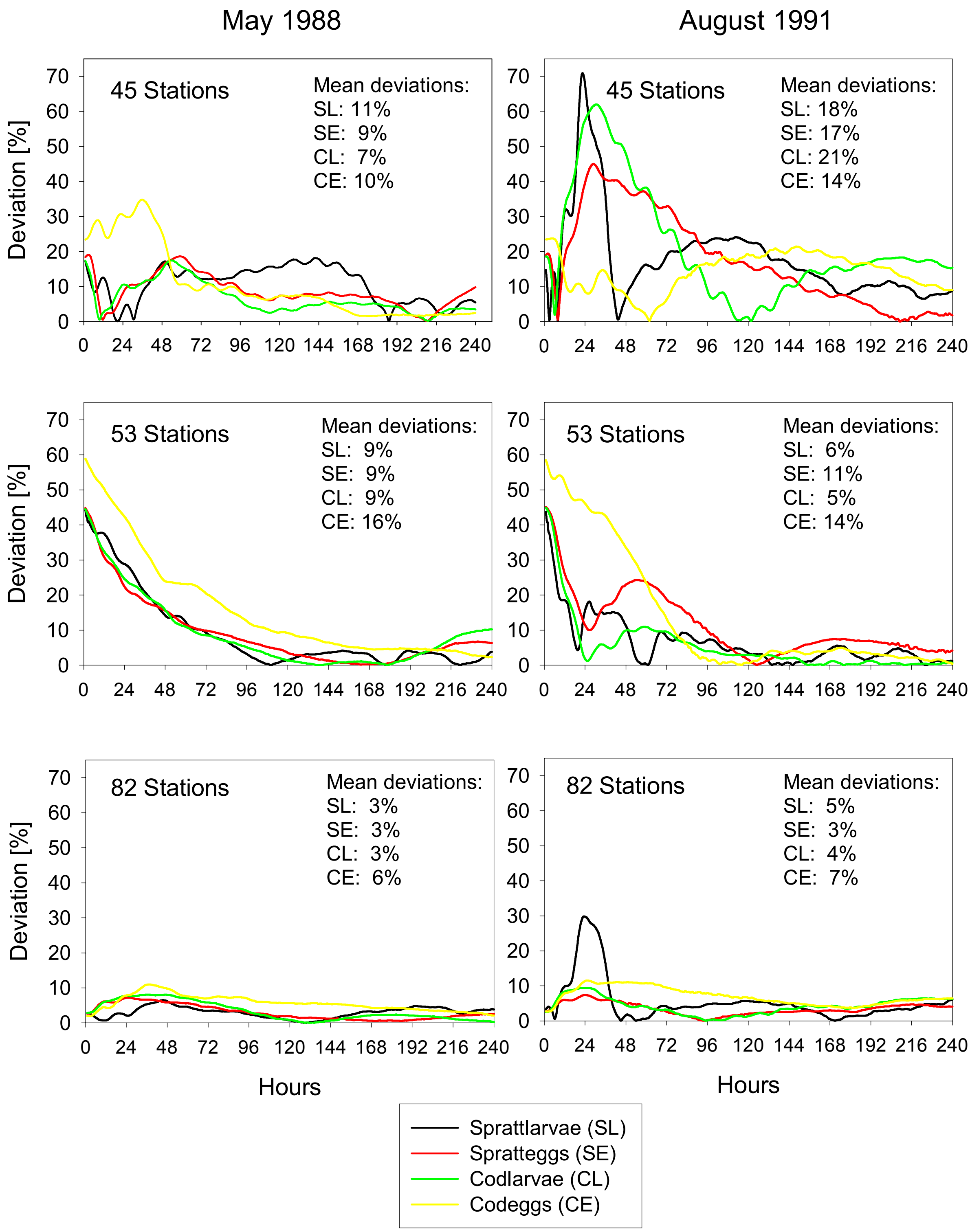


Fig. 2.1.35. Time series of abundance estimate errors due to the spatial sampling resolution over 10 days modelling time; comparison of 3 different station grids for May 1988 and Aug. 1991.

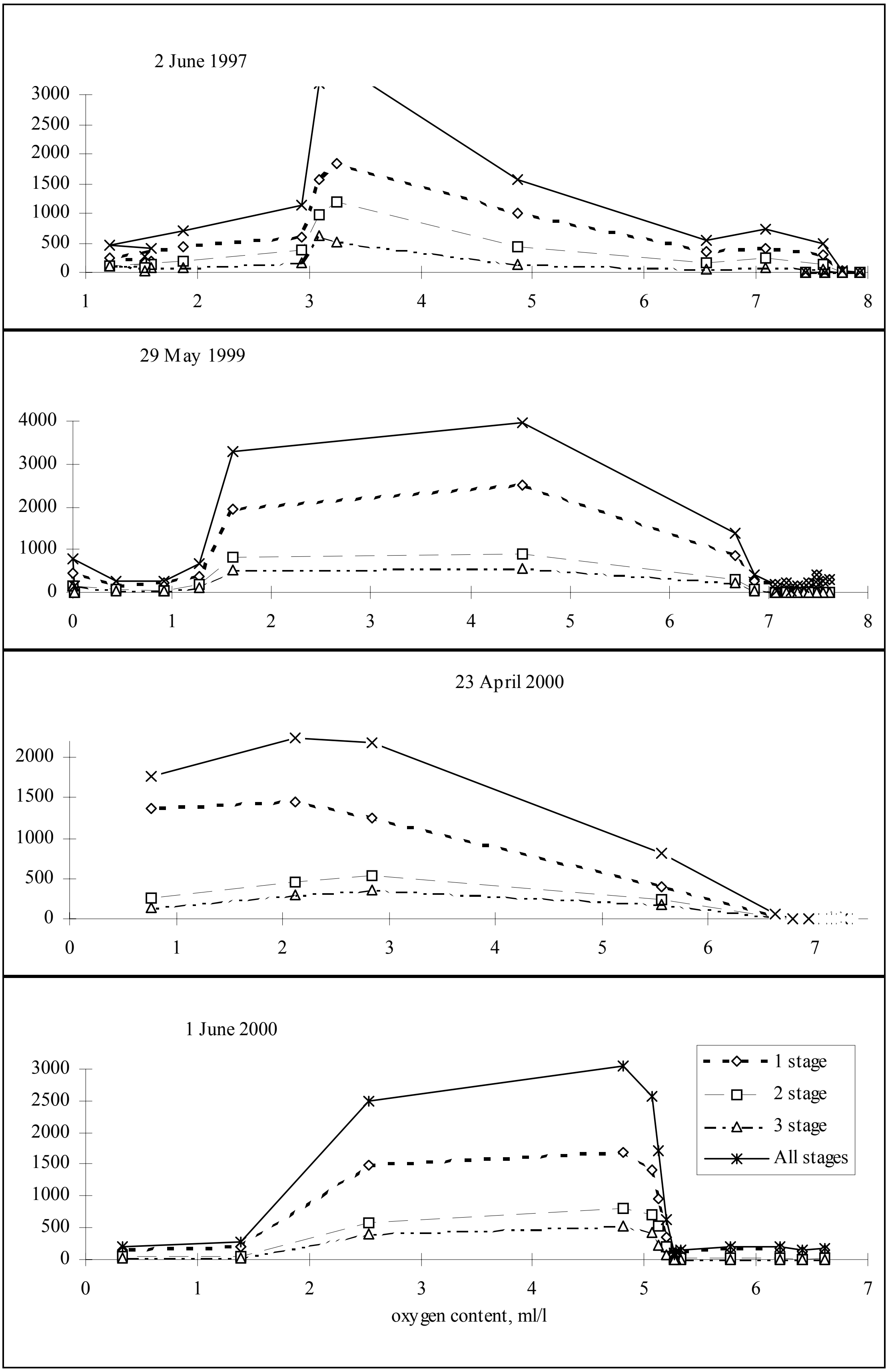


Figure 2.1.36. Abundance of sprat eggs (n/100m³) on different stages of development plotted against the oxygen content. BIOMOC studies. Gdansk Deep.

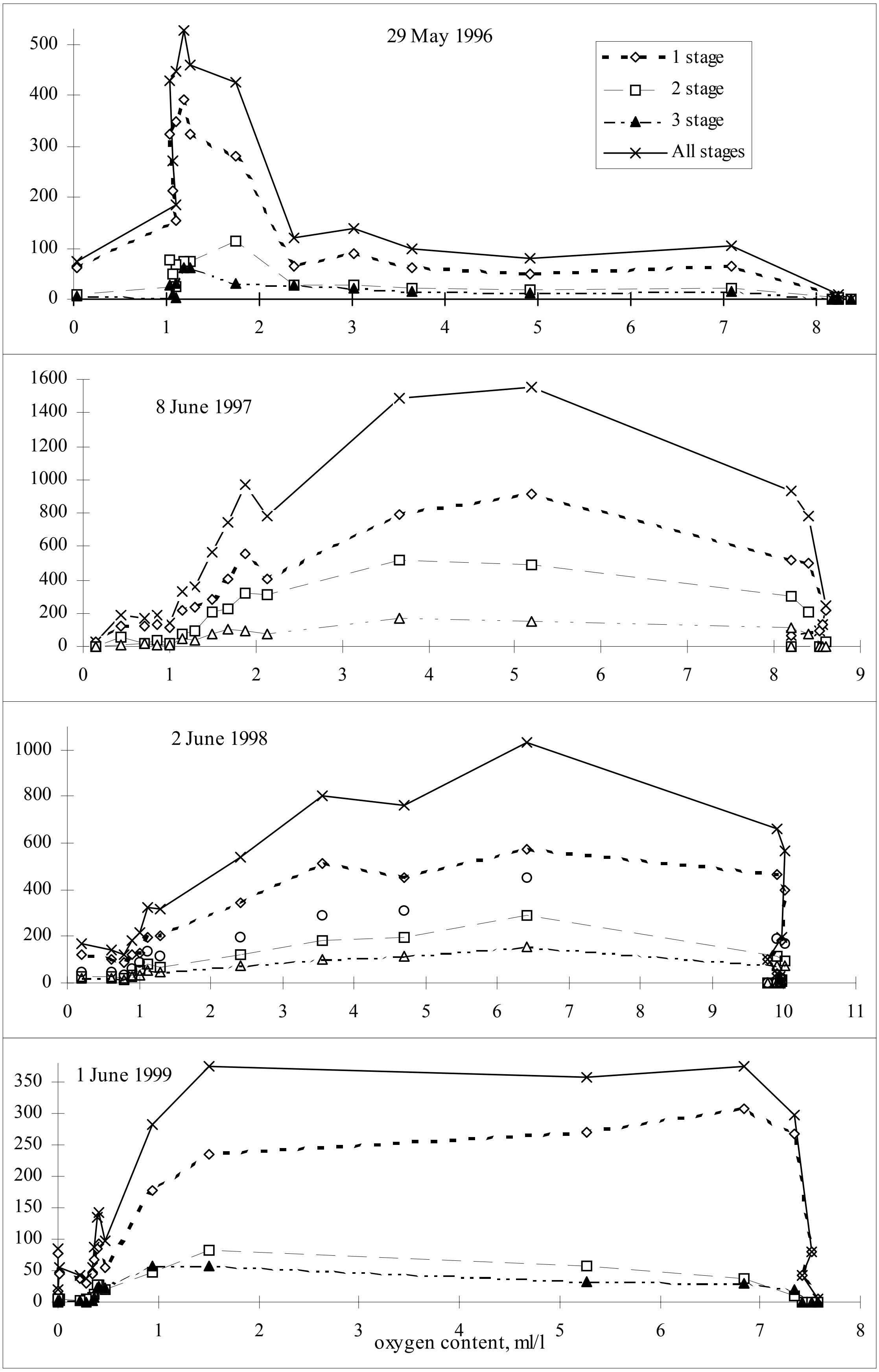


Figure 2.1.37. Abundance of sprat eggs (n/100m³) on different stages of development plotted against the oxygen content. BIOMOC studies. Gotland Basin.

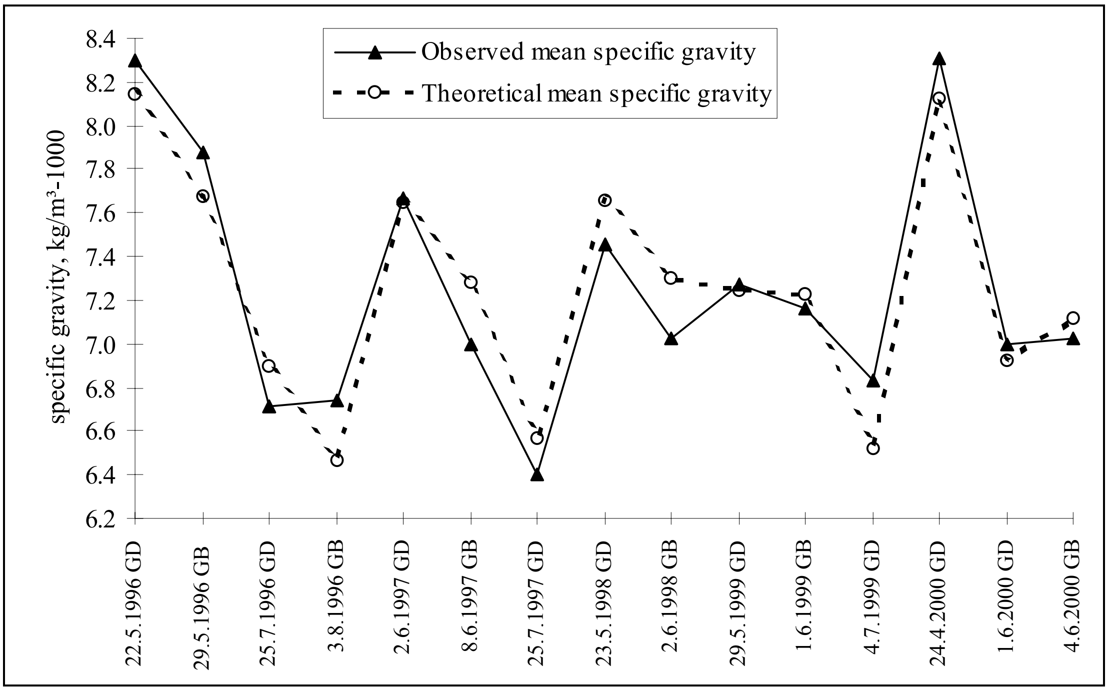


Figure 2.1.38. Mean weighted specific gravity of sprat eggs in the Eastern Baltic. Comparison of the model with the real data. GD stands for the Gdansk Deep, and GB stands for the Gotland Basin.

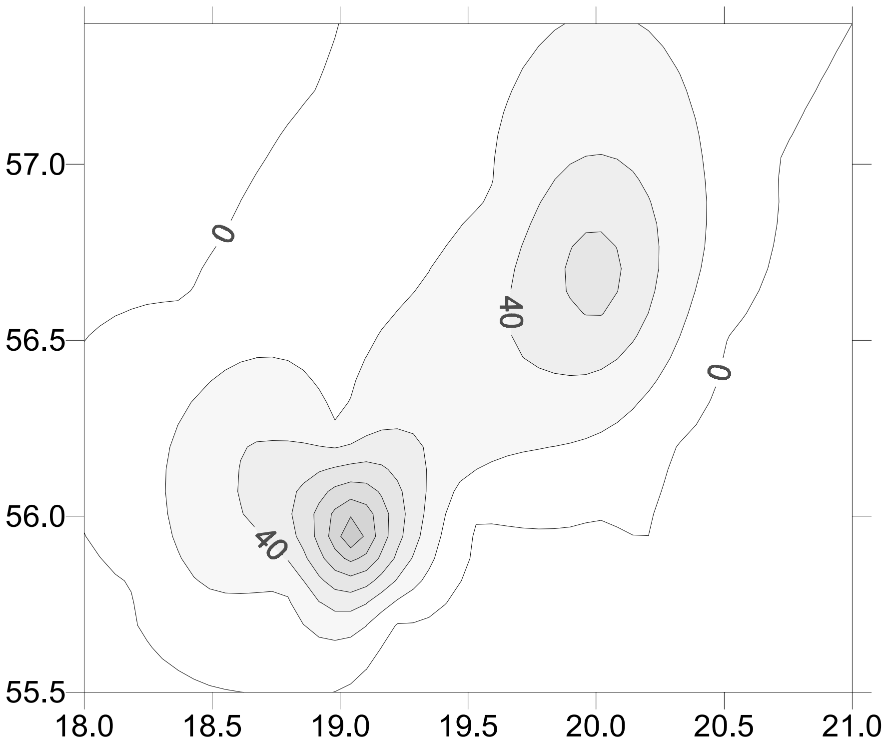


Figure 2.1.39. Daily production of sprat egg stage 1 in the Gotland Basin 19-20 April 1999.

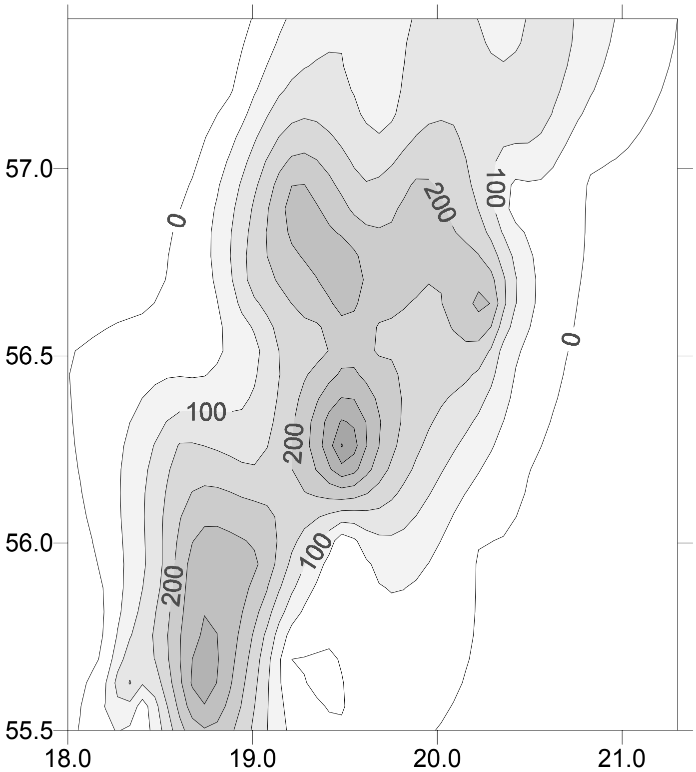


Figure 2.1.40. Daily production of sprat egg stage 1 in the Gotland Basin 28 May- 2 June 1999.

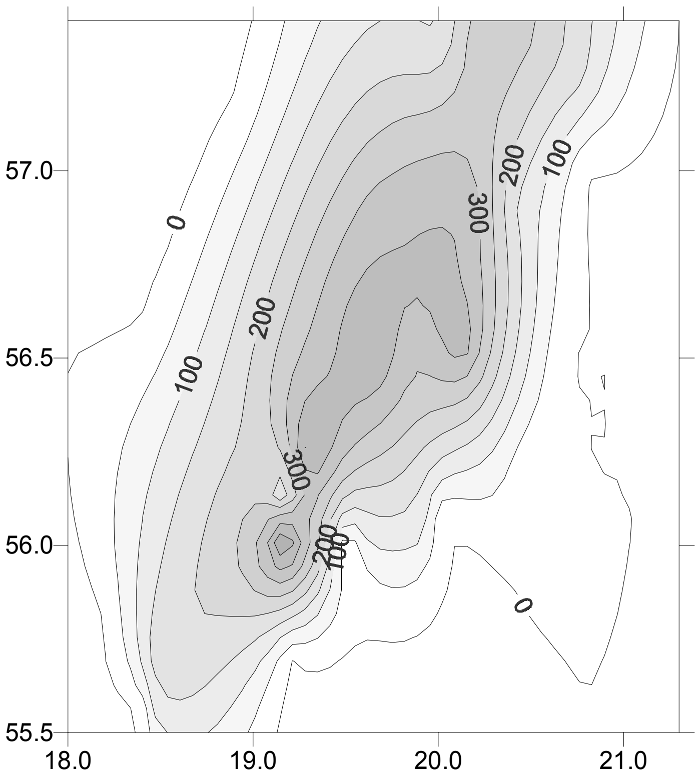


Figure 2.1.41. Daily production of sprat egg stage 1 in the Gotland Basin 19-20 June 1999.

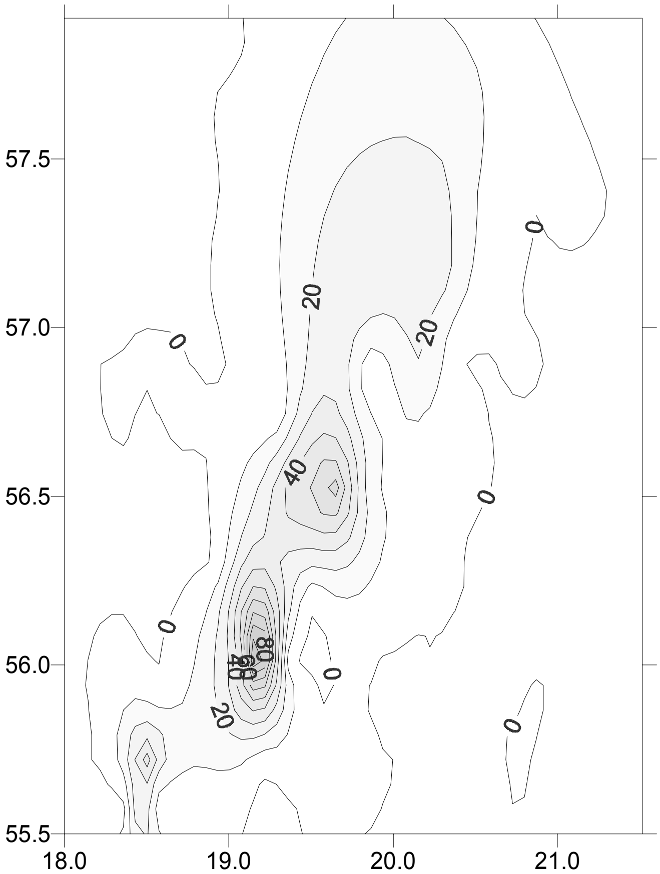


Figure 2.1.42. Daily production of sprat egg stage 1 in the Gotland Basin 3 May 2000.

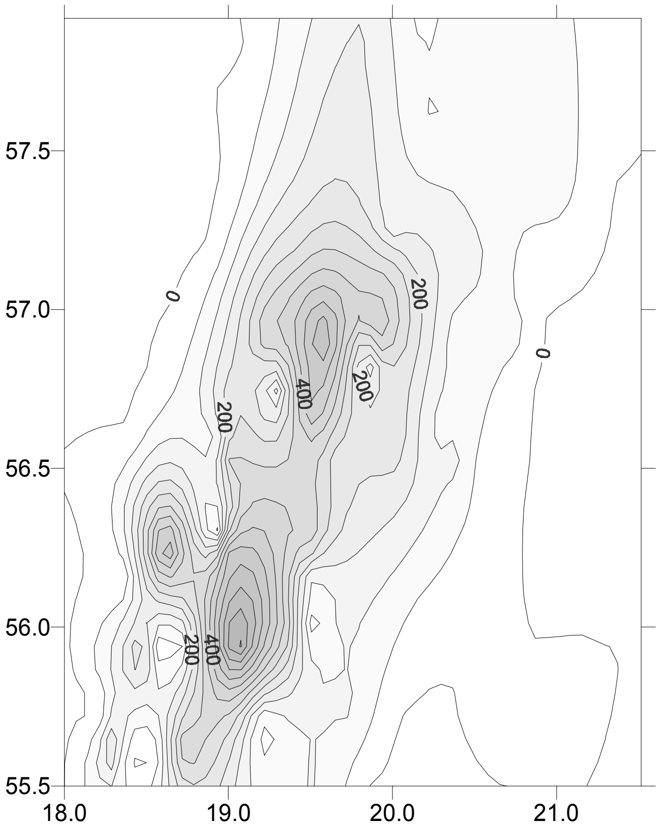


Figure 2.1.43. Daily production of sprat egg stage 1 in the Gotland Basin 30 May-4 June 2000.

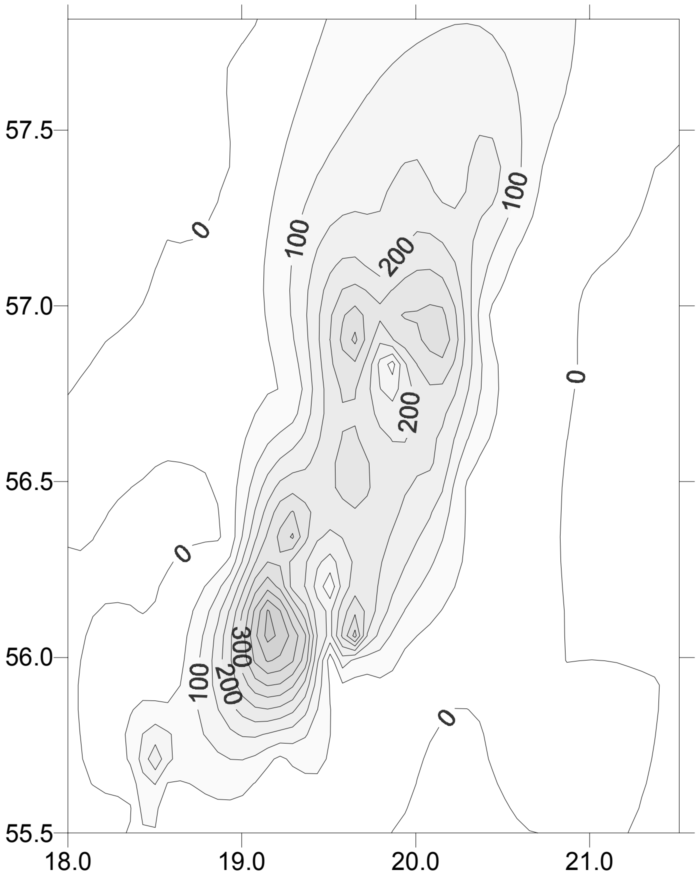


Figure 2.1.44. Daily production of sprat egg stage 1 in the Gotland Basin 17-20 June 2000.

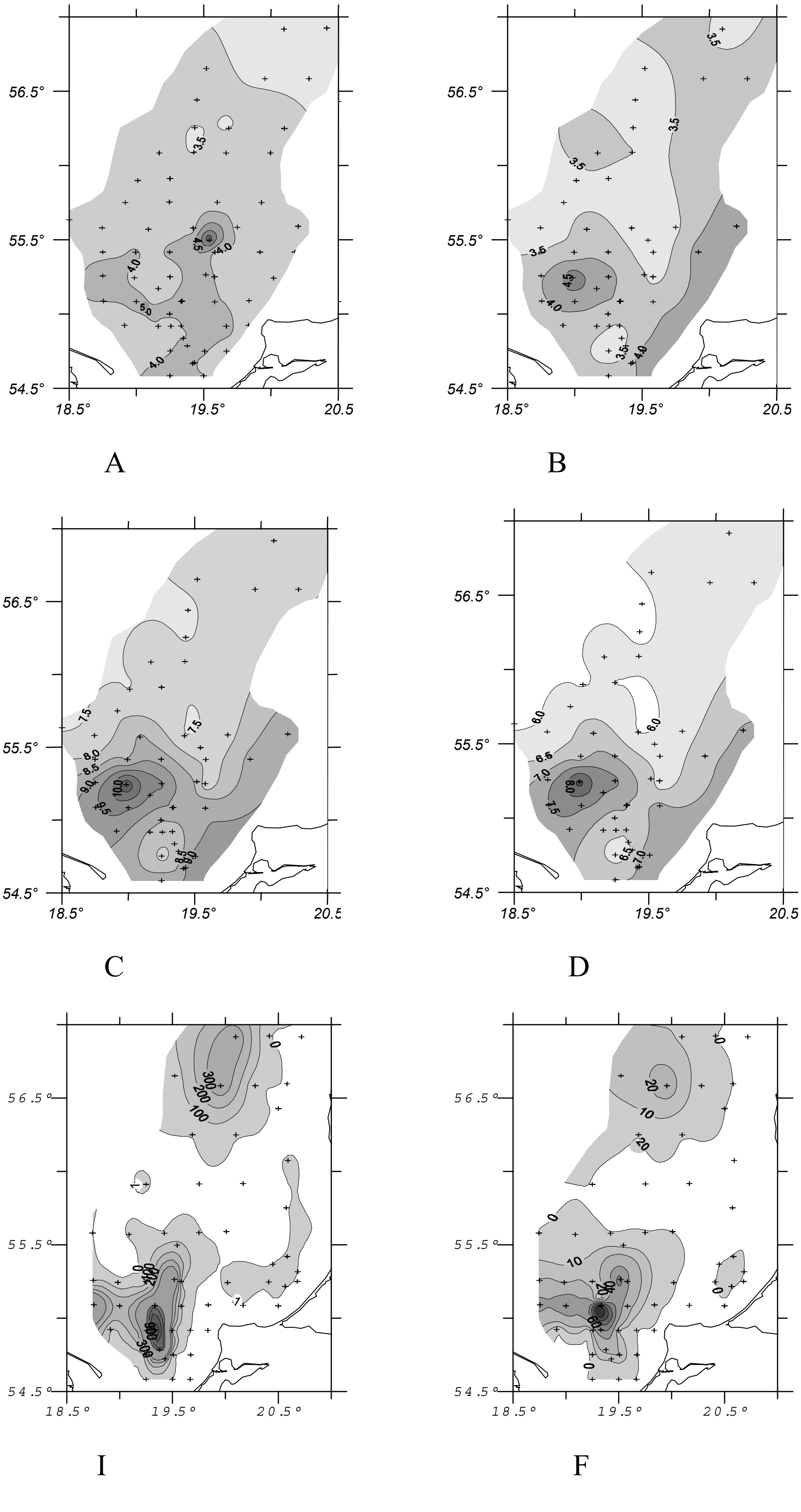


Fig. 2.1.45. The spatial distribution: A - T °C at 20 м ; B - T °C at 70 м;
C - salinity at 70 м; D - water density at 70 м; I - sprat eggs (sp/m^2);
F - sprat larvae (sp/m^2). 15.04. - 09.05. 1993

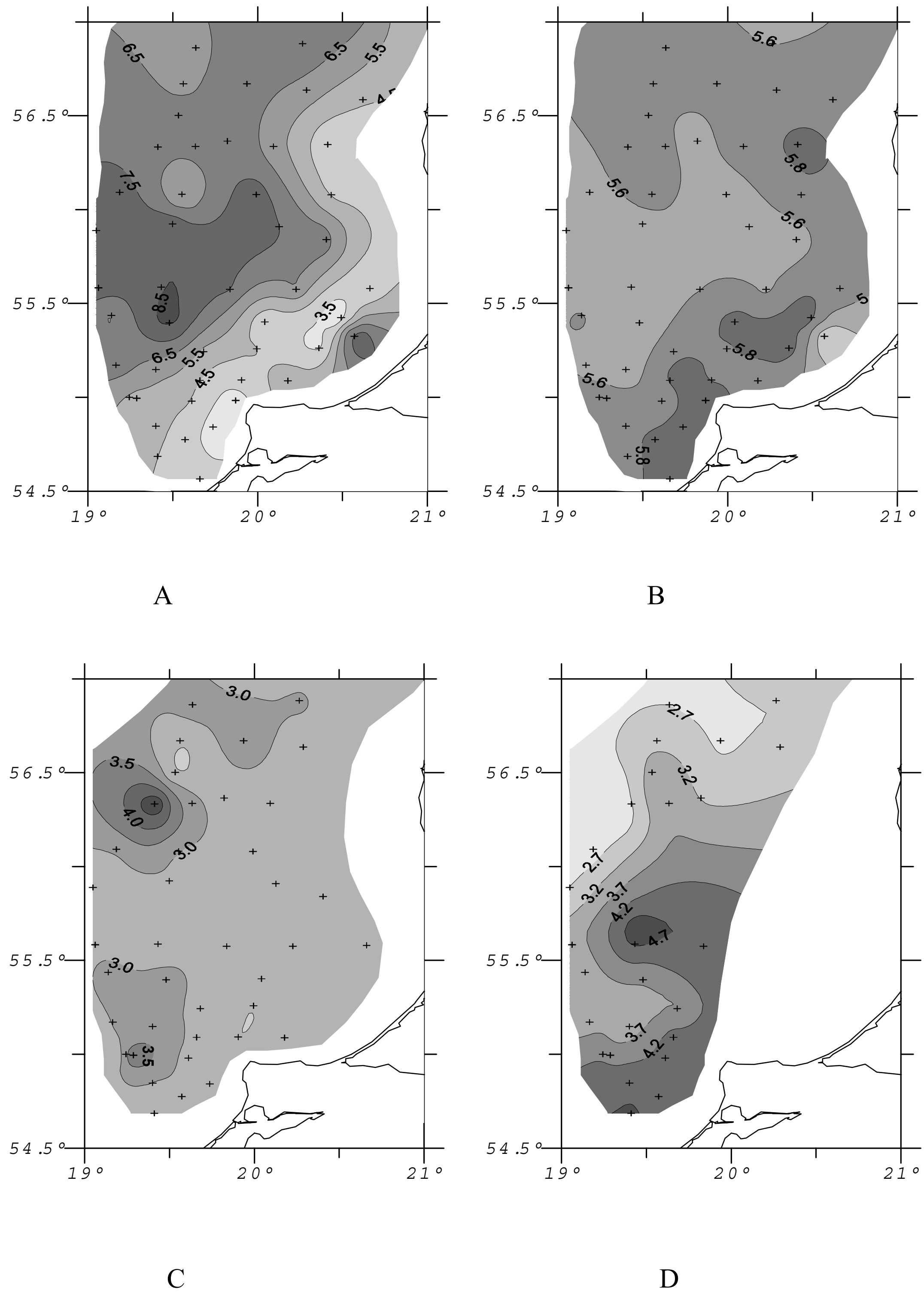


Fig. 2.1.46. The spatial distribution: A - T °C at 20 м; B - water density at 20 м;
C - T °C at 40 м; D - T °C at 70 м. 24.05.-02.06.1994

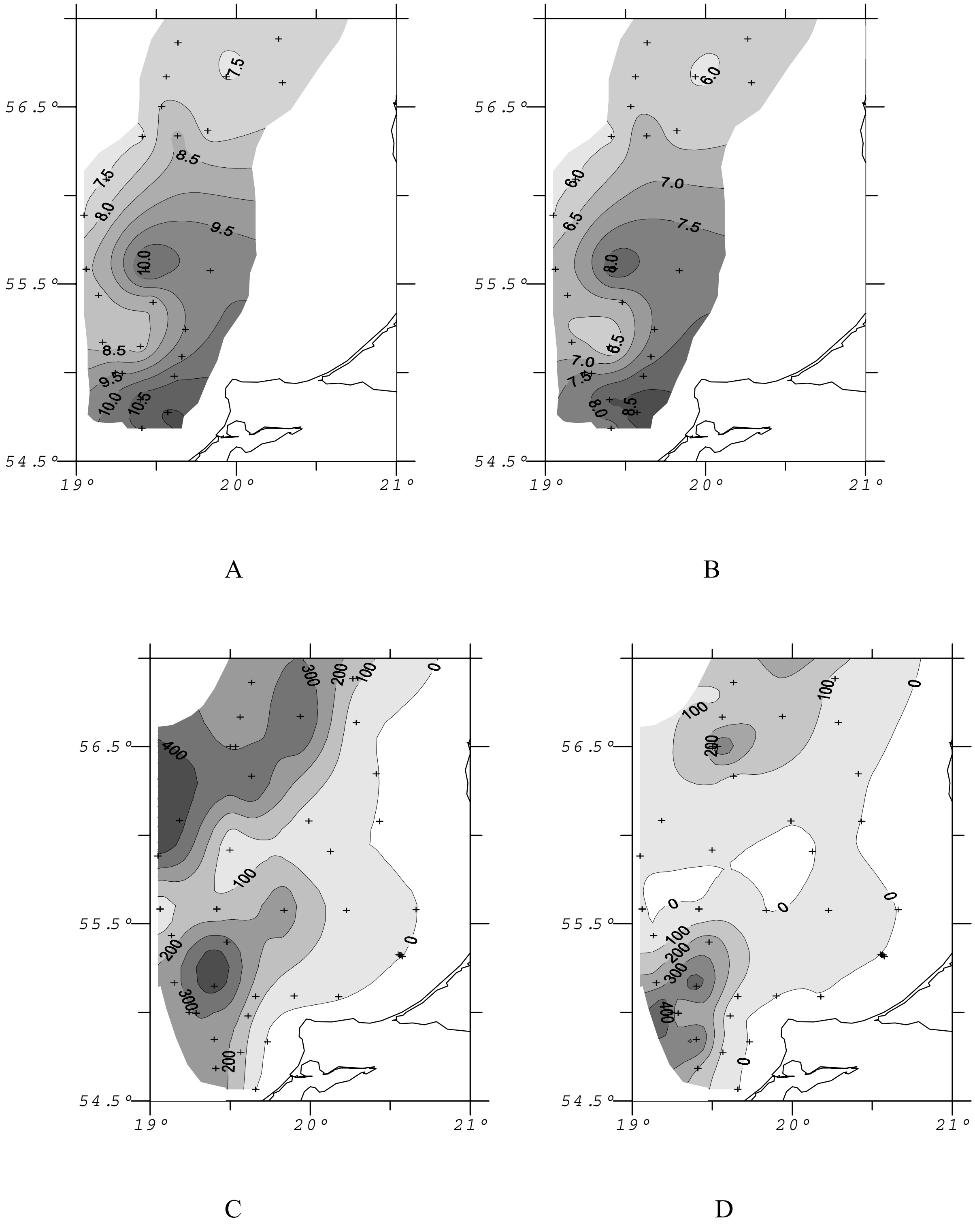


Fig.2.1.47. The spatial distribution: A - salinity at 70 м; B - water density at 70 м;
C -sprat eggs (sp/m^2); D - sprat larvae (sp/m^2). 24.05-02.06 1994

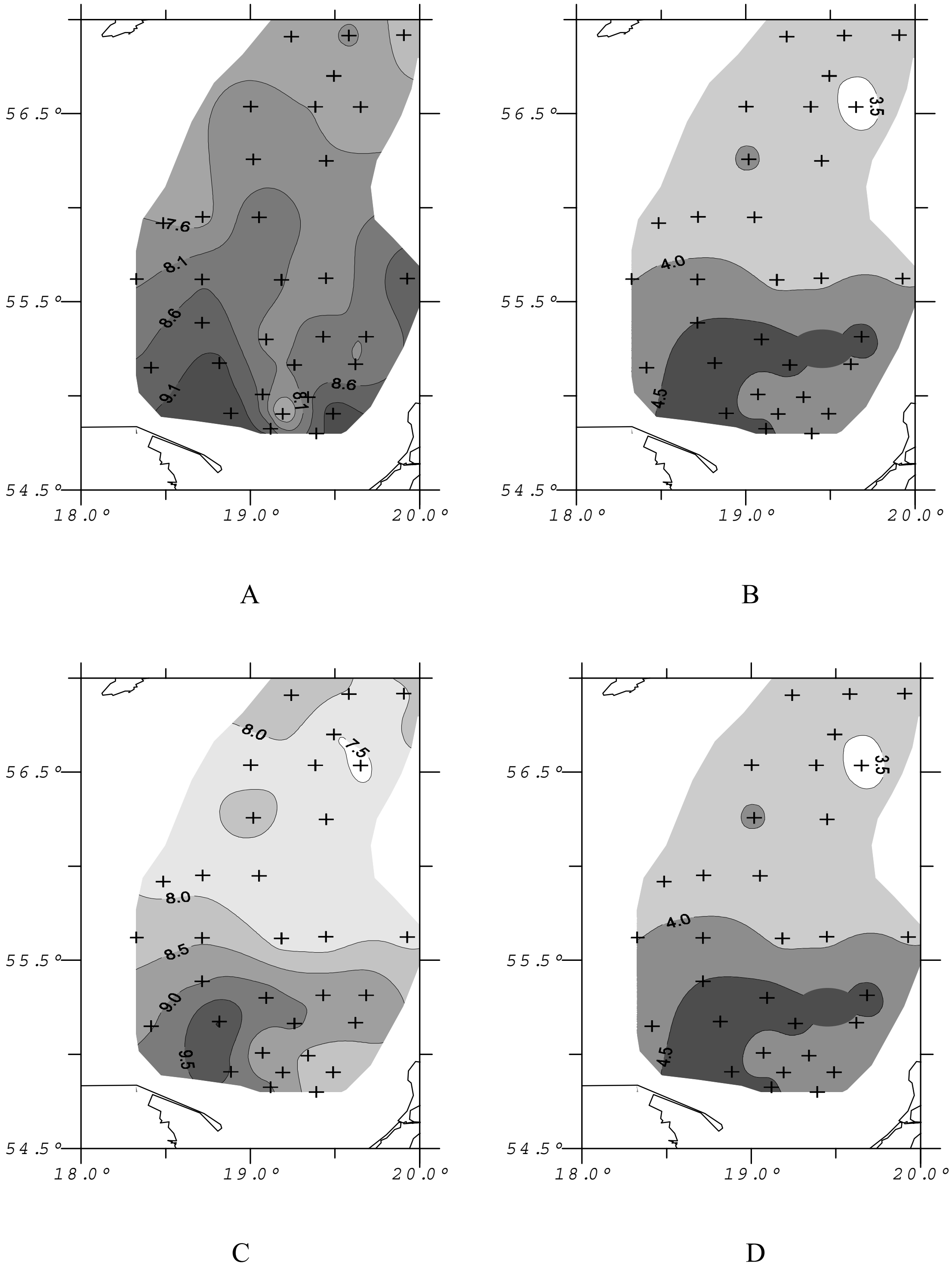


Fig. 2.1.48. The spatial distribution: A - T °C at 20 м; B - T °C at 70 м; C - salinity at 70 м; D - water density at 70 м. 23.05-02.06.1998

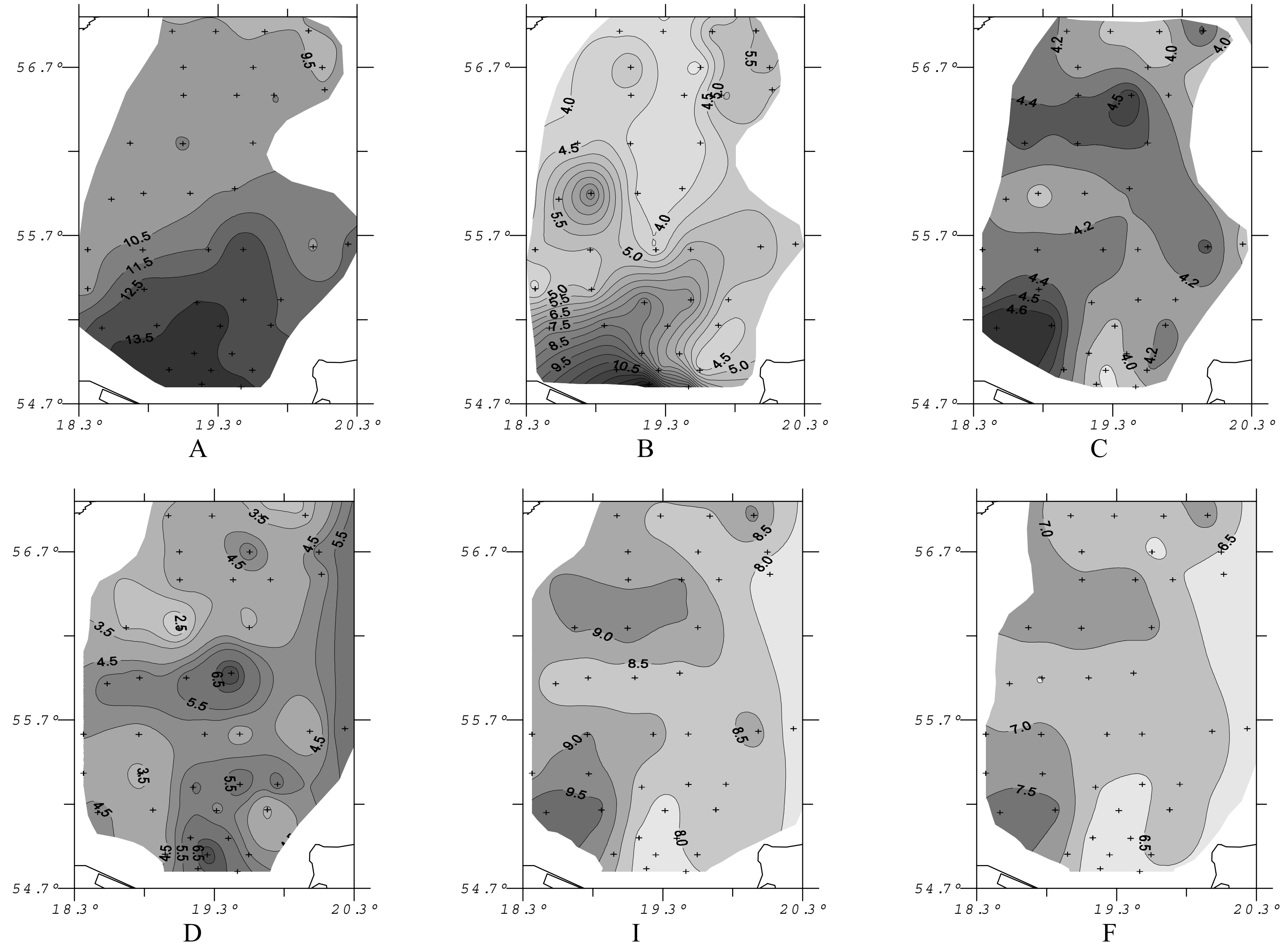


Fig.. 2.1.49. The spatial distribution: A - T°C at 20 м; B - T °C at 40 м; C - T °C at 70 м; D - oxygen content (ml/l) at 70 м; I - salinity at 70 м; F - water density at 70 м. 11-15.07. 1998

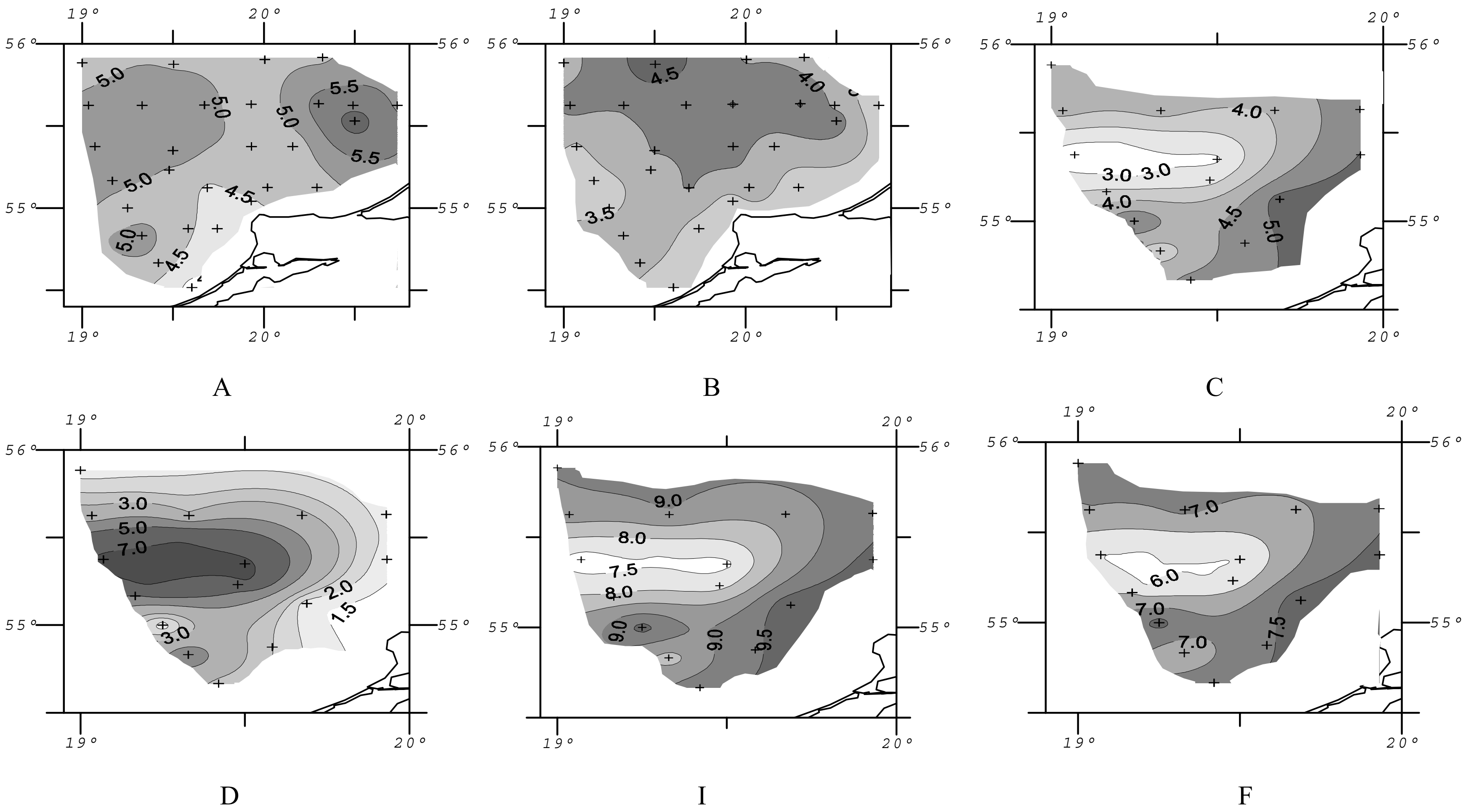


Fig. 2.1.50. The spatial distribution: A - T °C at 20 м; B - T °C at 40 м; C - T °C at 70 м; D - oxygen content (ml/l) at 70 м; **I** - salinity on 70 м; F - water density at 70 м. 08-15.05 1999

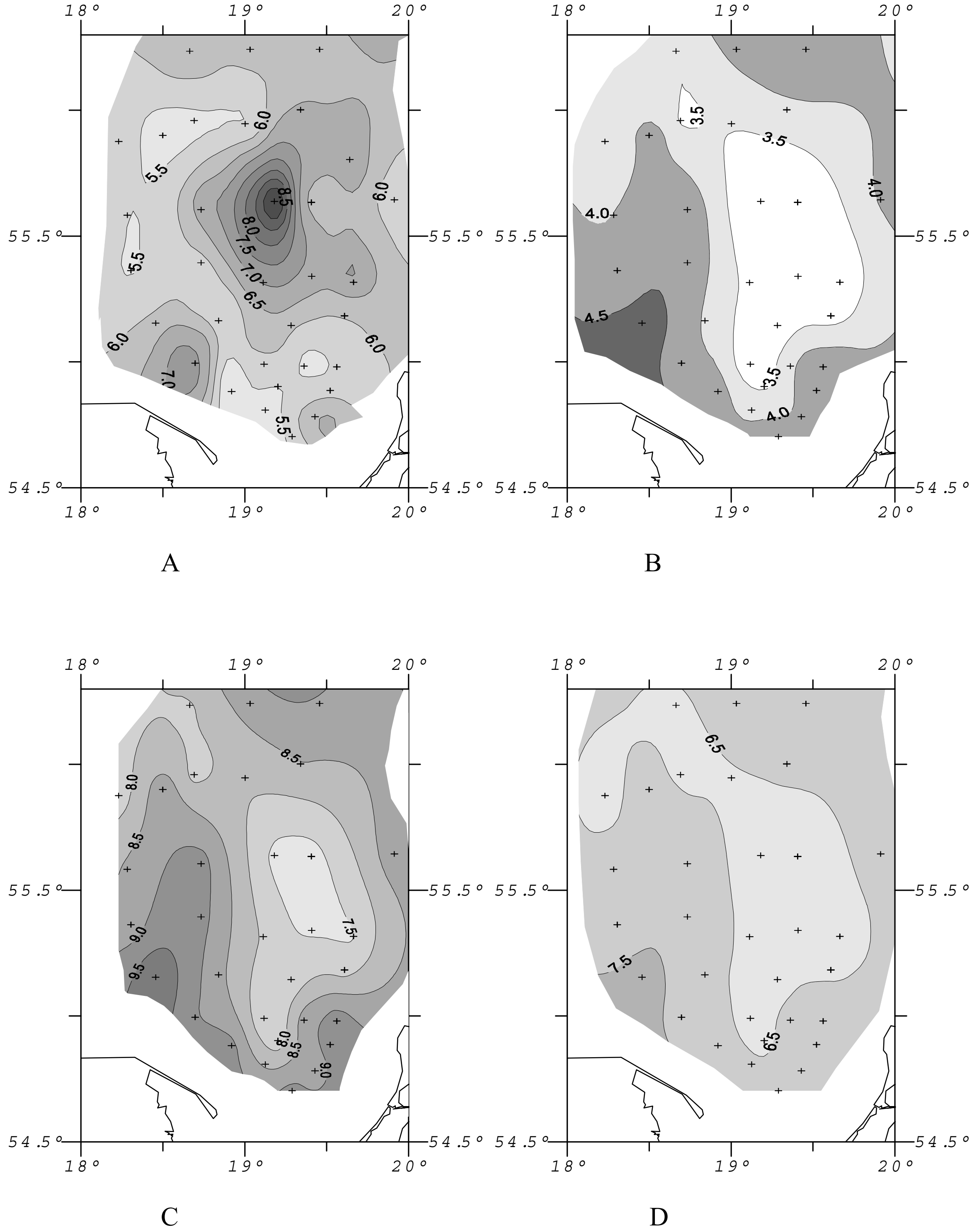


Fig. 2.1.51. The spatial distribution: A - T °C at 20 м; B - T °C at 70 м;
C - salinity at 70 м; D - water density at 70 м. 28.05-01.06. 1999

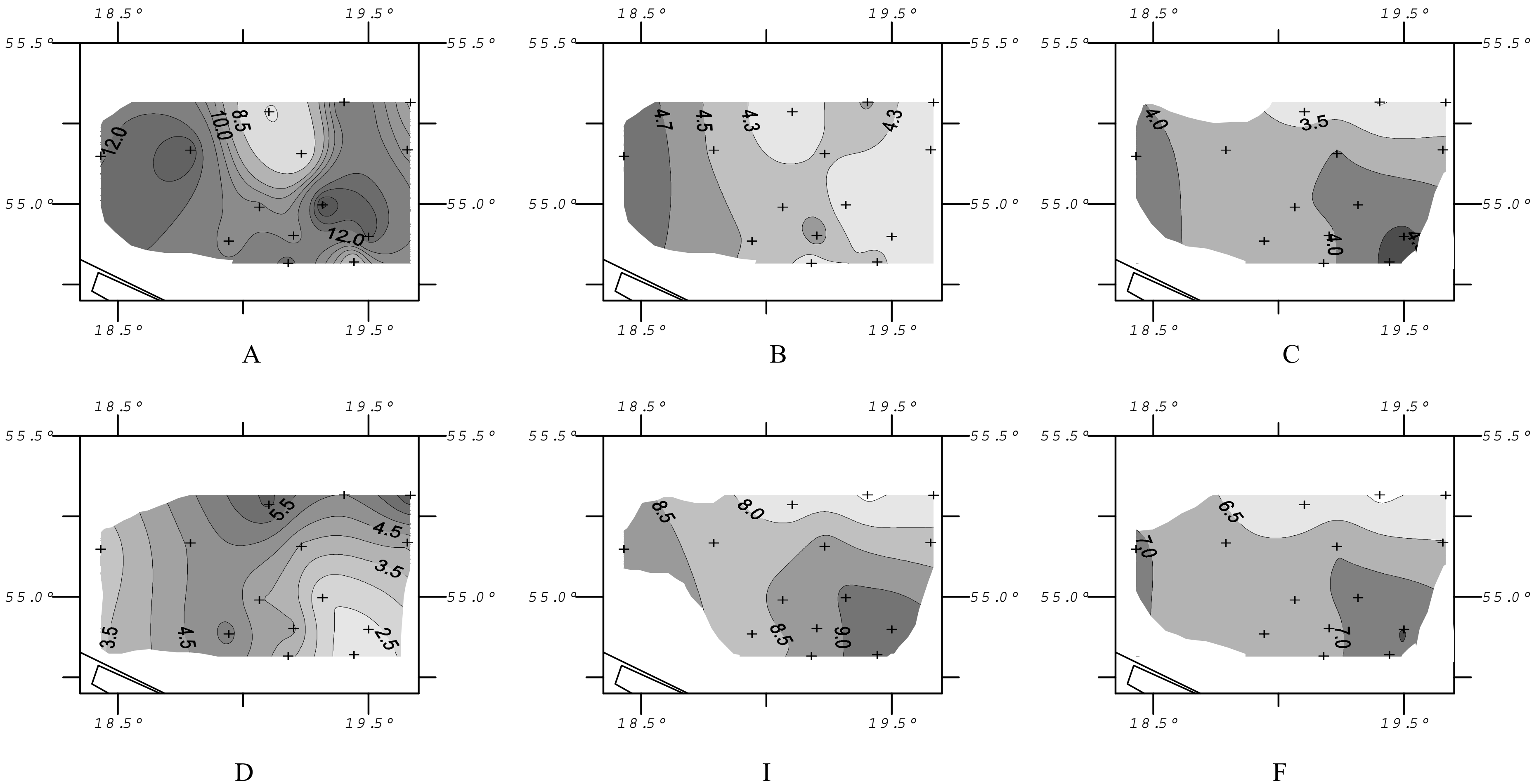


Fig. 2.1.52. The spatial distribution: A - T °C at 20 м; B - T °C at 40 м; C - T °C at 70 м; D - oxygen content at 70 м; I - salinity at 70 м, F - water density 70 м. 03-05.07 1999

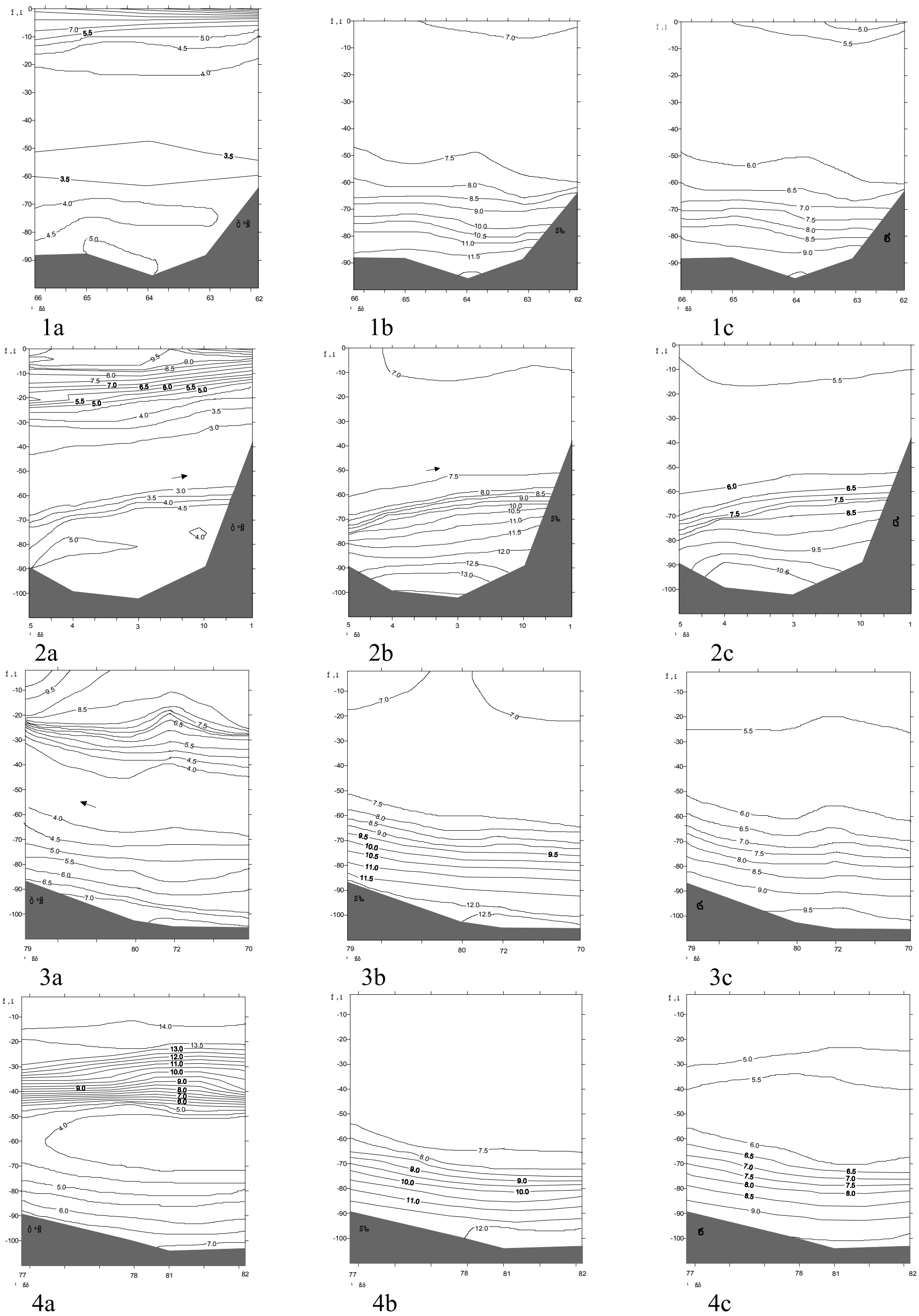


Fig. 2.1.53. The vertical distribution of isoterms (a), isohalines (b) and isopycnics (c) at cross transect in the Gdansk Deep:

1.55°05 N, 18°45 E — 55°05 N, 19°50 E, 30.04.-01.05. 93
2. 55°10 N, 19°09 E — 54°34 N, 19°40 E, 24-25. 05. 94
3. 55°10’ N, 18°49 E — 54°48’ N, 19°23 E, 23-24. 05. 98
4. 55°10’ N, 18°49 E — 54°48’ N, 19°25 E, 9-11.07. 98

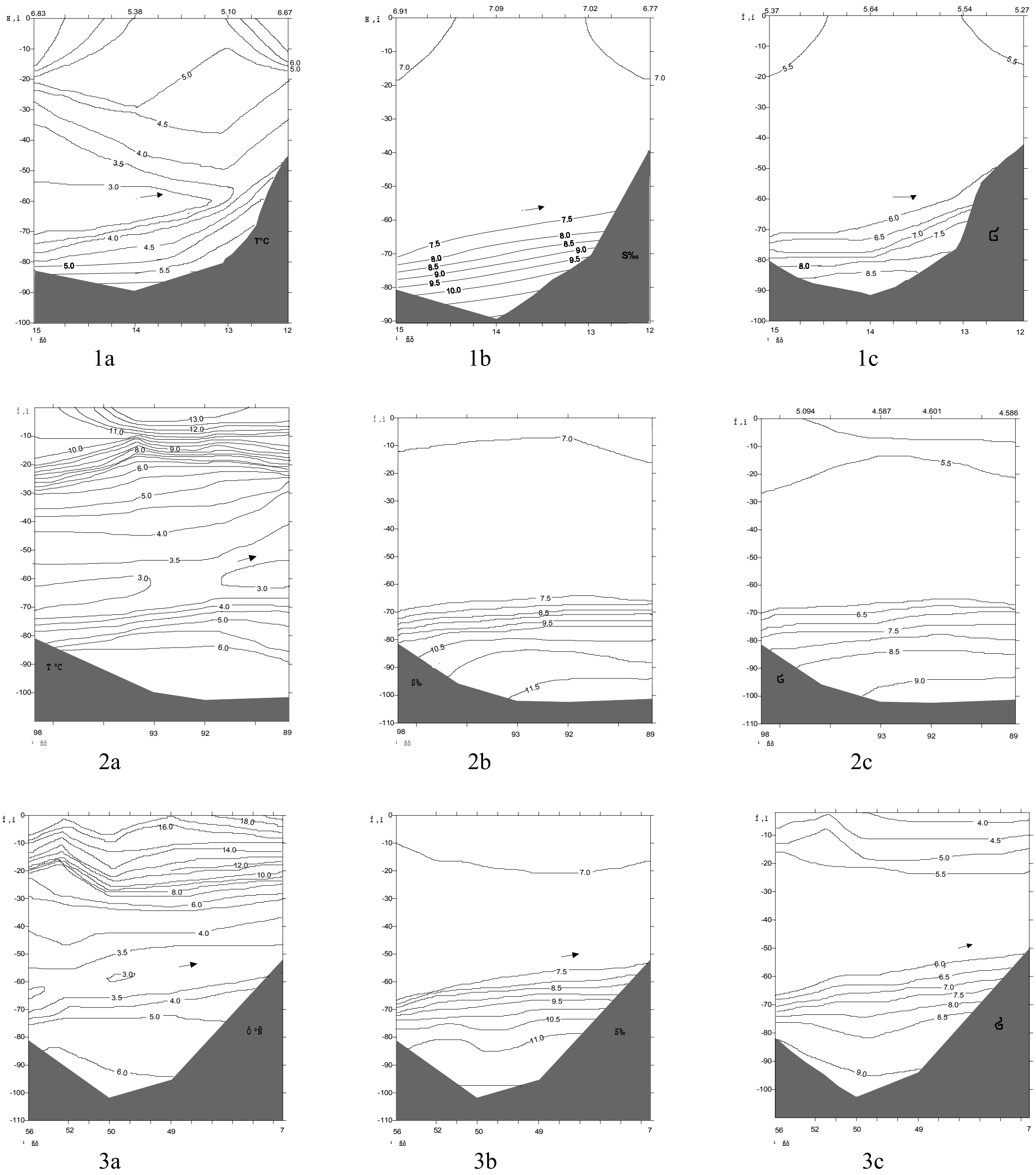


Fig. 2.1.54. The vertical distribution of isoterms (a), isohalines (b) and isopycnics(c) at cross transect in the Gdansk Deep:

1. 55°22’5 N, 19°04’2 E — 55°22’5 N, 20°09’5 E, 11.05.99
2. 55°38 N, 19°11 E — 54°47 N, 19°26 E, 30-31. 05. 99
3. 55°17 N, 19°06 E — 54°52 N, 19°43 E, 04-06. 07. 99

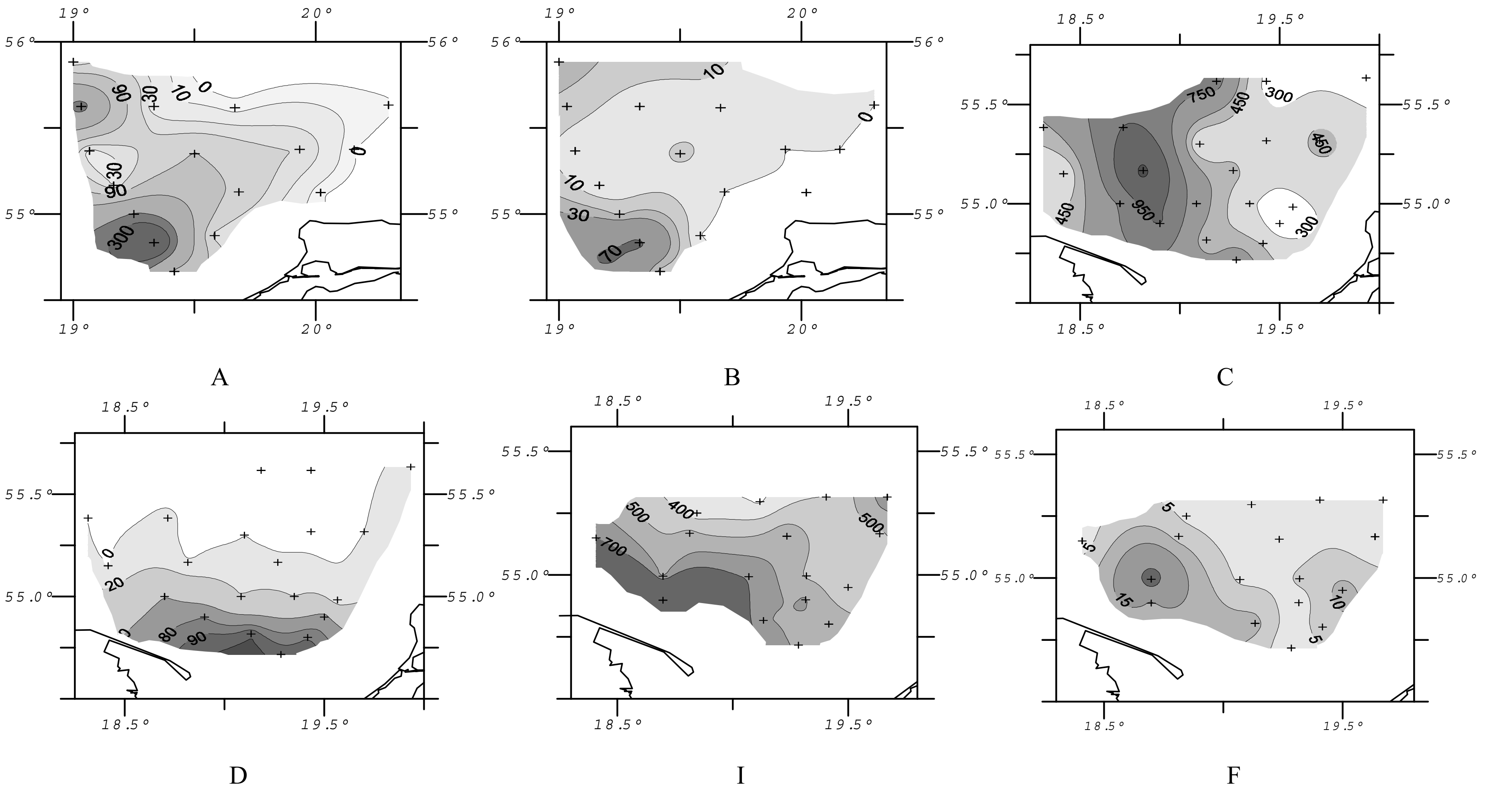


Fig. 2.1.55. The spatial distribution: A - sprat eggs (sp/m^2), 08-15.05; B - sprat larvae (sp/m^2), 08-15.05;
C - sprat eggs (sp/m^2), 27-31.05; D - sprat larvae (sp/m^2), 27-31.05; I - sprat eggs (sp/m^2), 03-05.07; F - sprat larvae (sp/m^2), 03-05.07

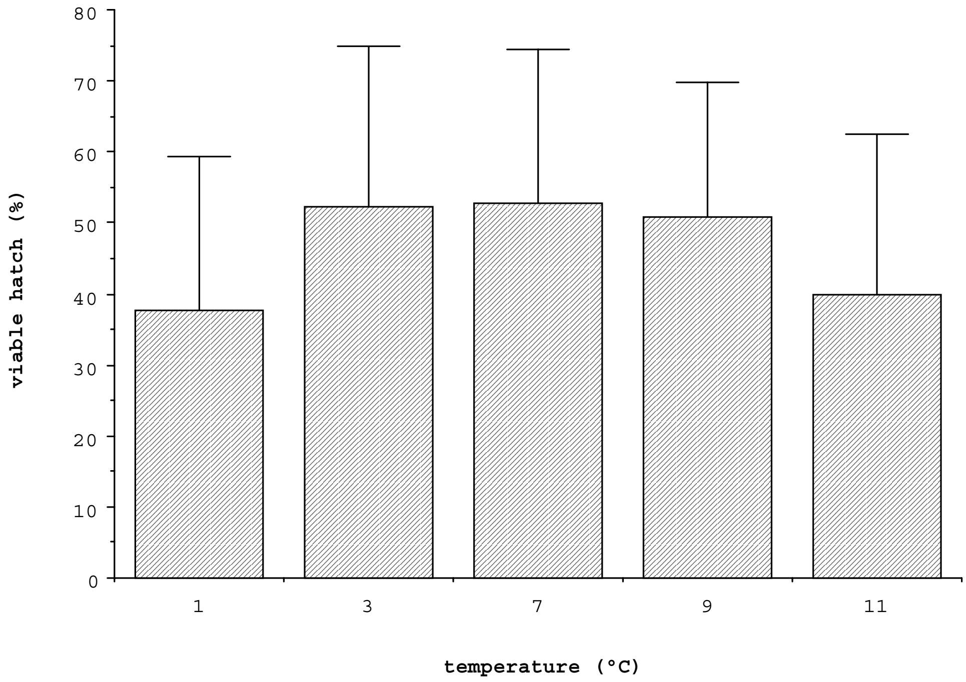


Fig. 2.2.1. Viable hatch of Baltic cod at different temperatures (n=9). Average±sd.

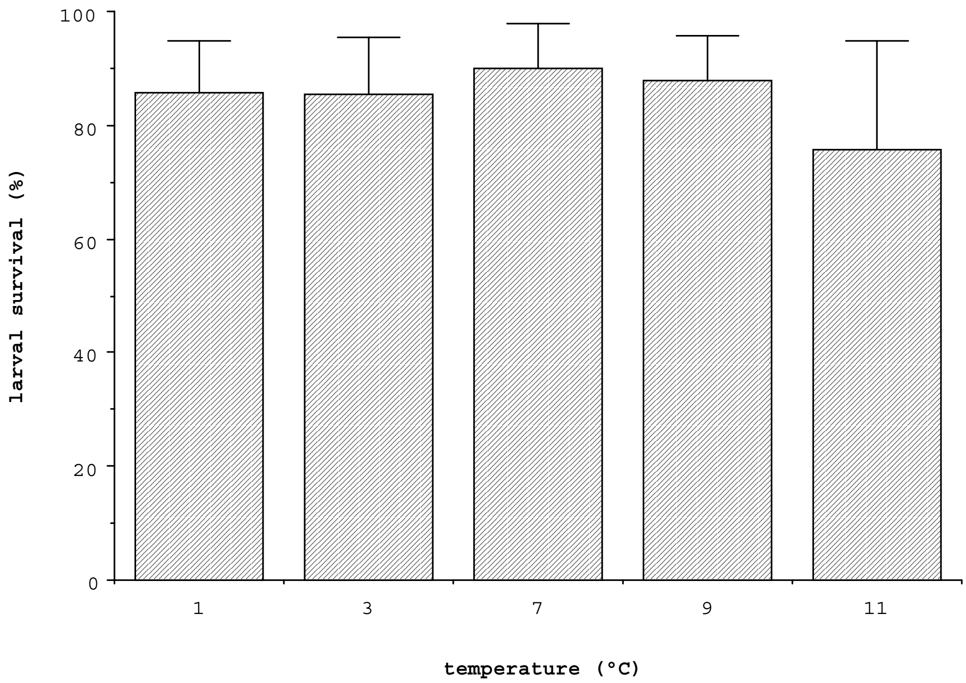


Fig. 2.2.2. Larval survival of Baltic cod during the yolk sac stage at different temperatures (n=9). Average±sd.

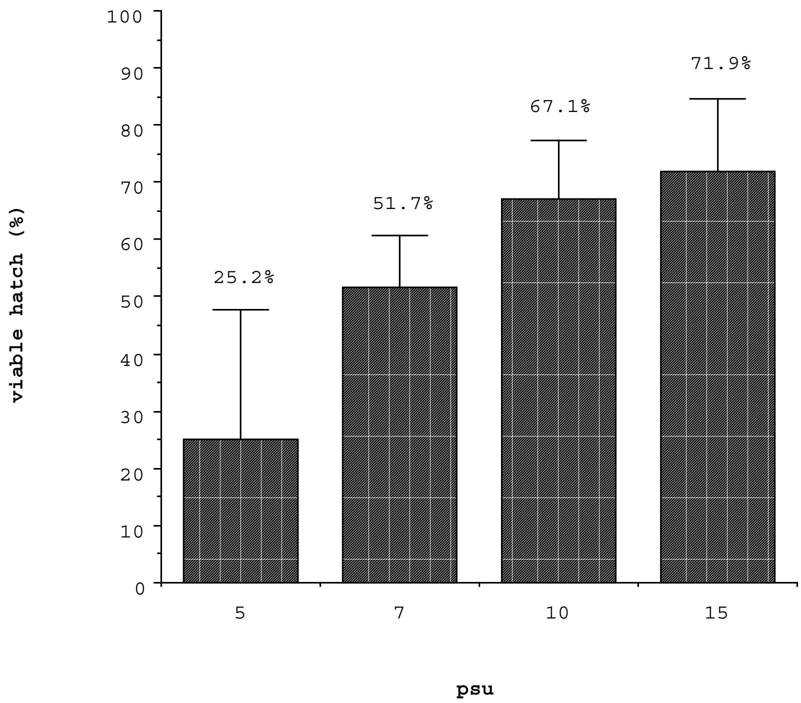


Fig. 2.2.3. Viable hatch of Baltic sprat at different salinities (n=4). Average±sd.

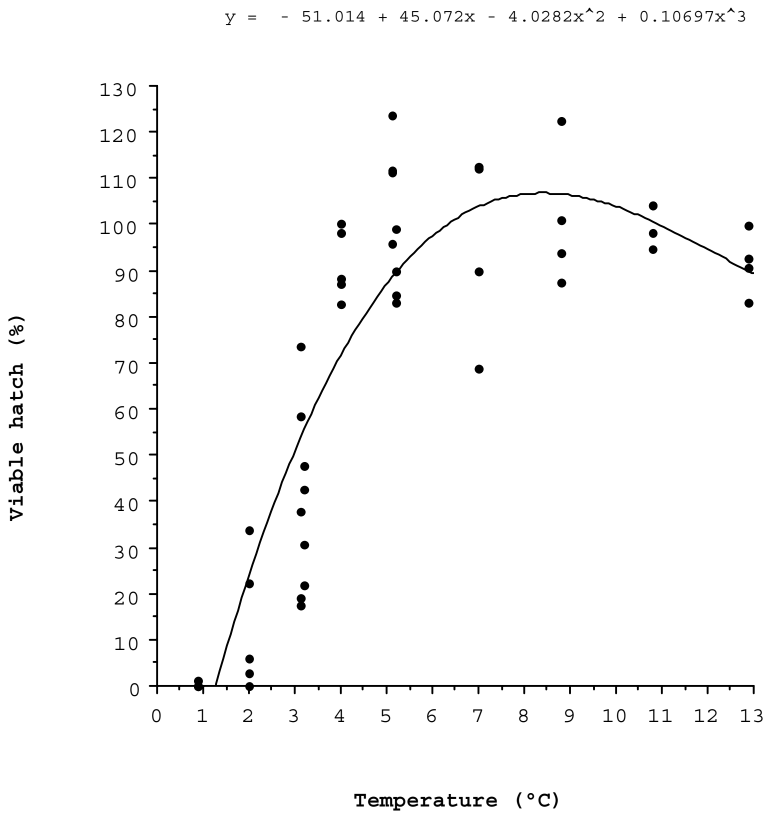


Figure 2.2.4. Viable hatch of Baltic sprat at different temperatures, calculated in relation to egg survival at 5°C.

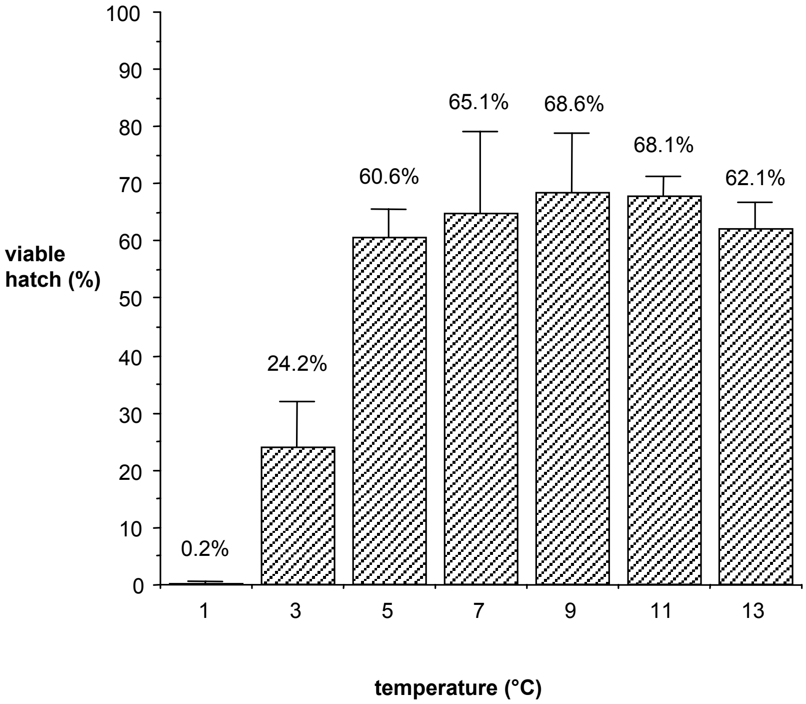


Fig. 2.2.5. Viable hatch of Baltic sprat at different temperatures (n=4). Average±sd.

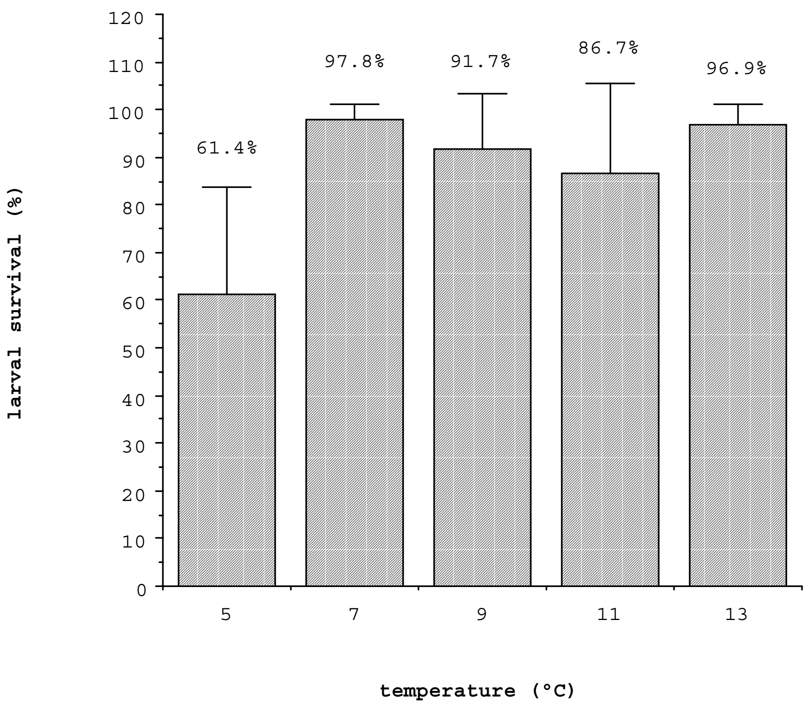
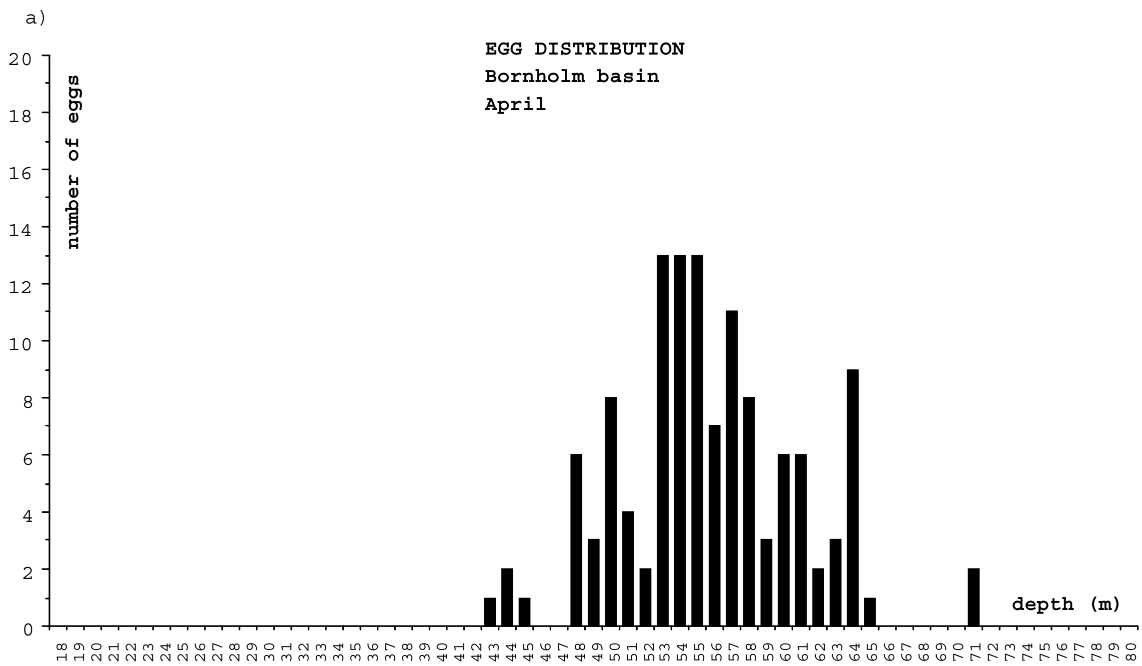
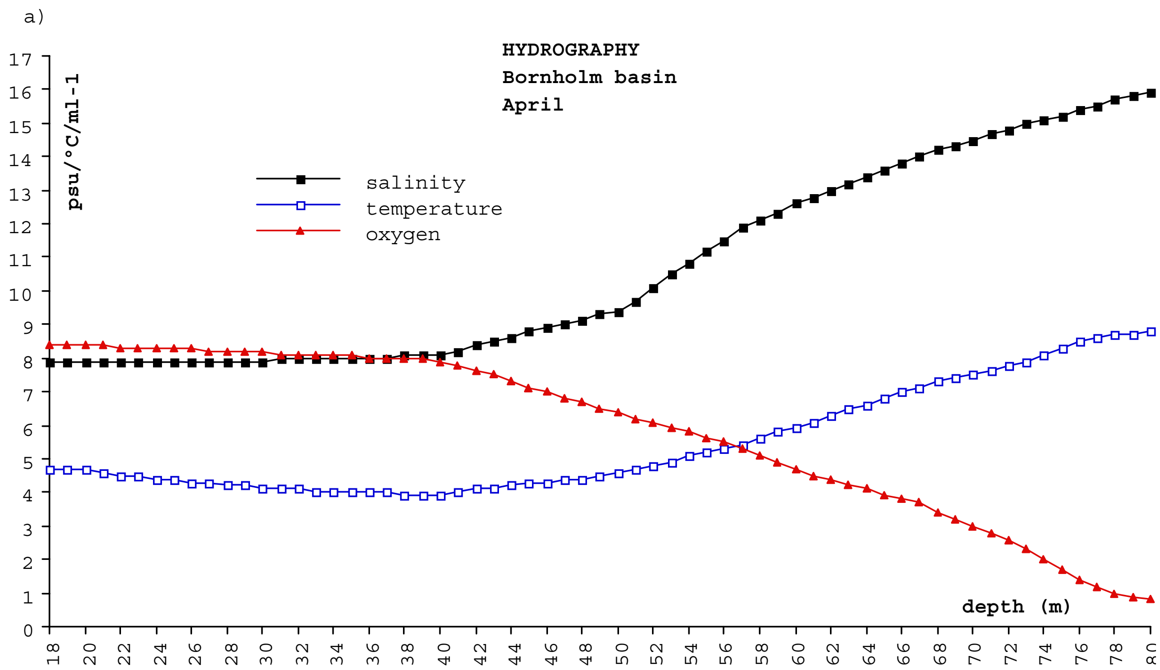


Fig. 2.2.6. Larval survival during the yolk sac stage of Baltic sprat at different temperatures (n=2). Average±sd.





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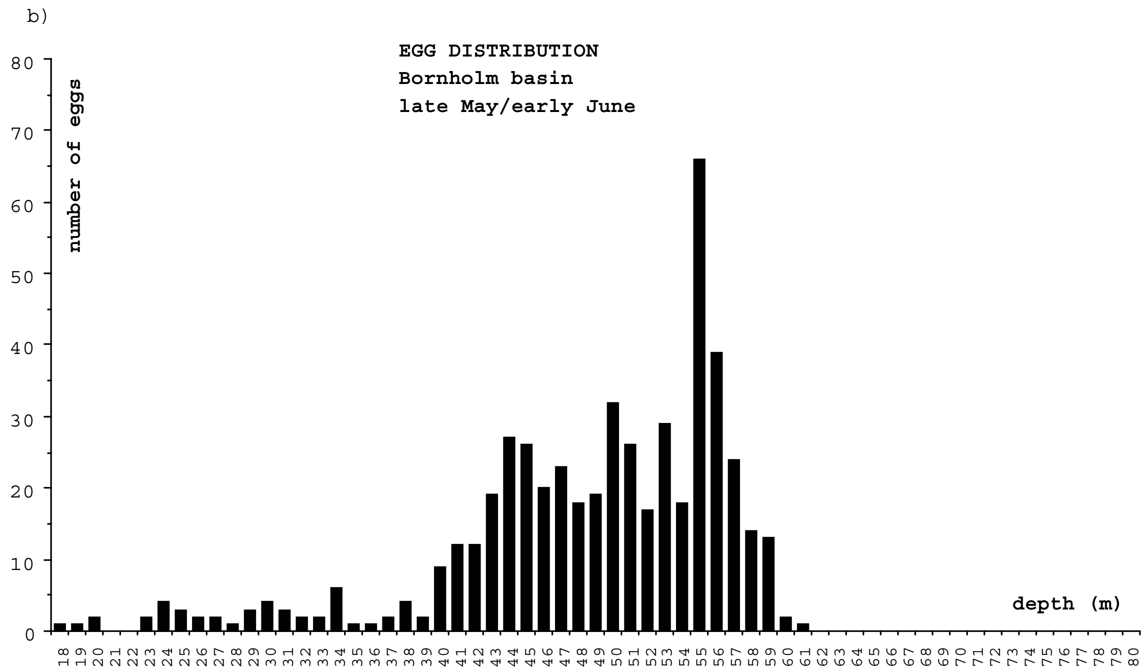


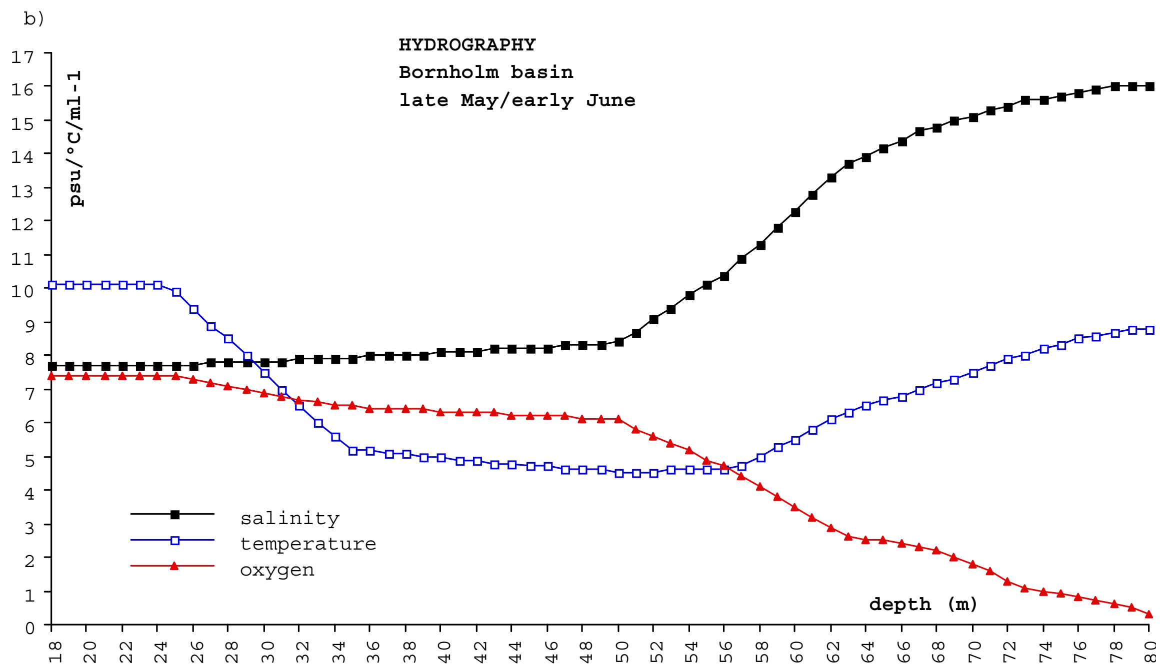
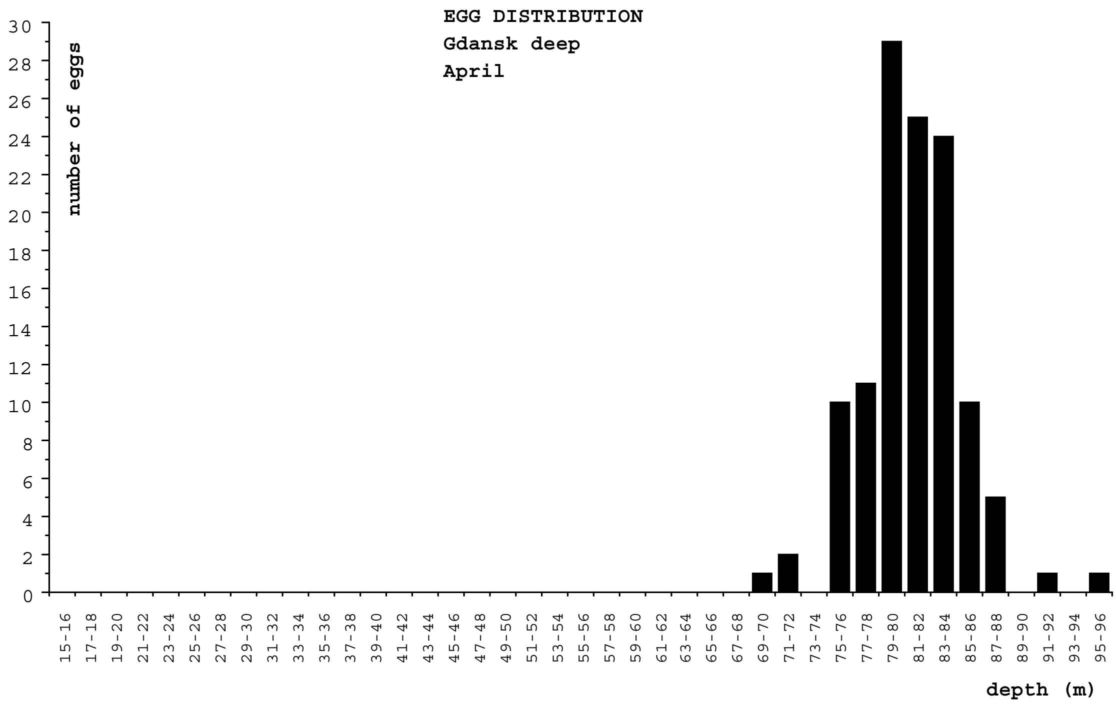
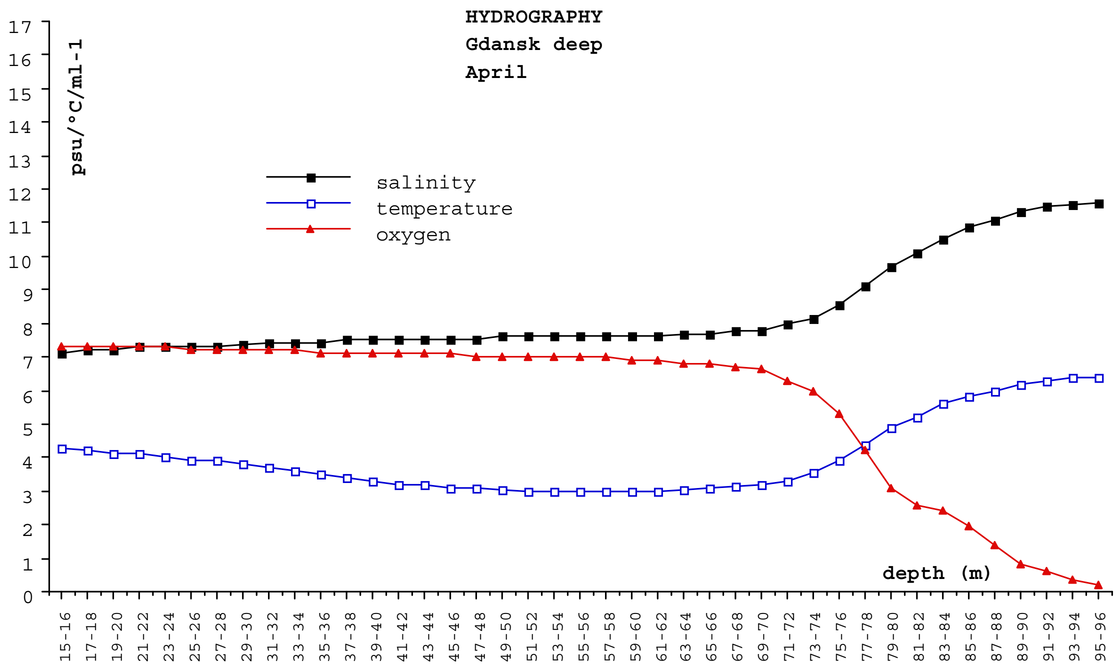


Fig. 2.2.7. Vertical distribution of sprat eggs and corresponding profiles of salinity, temperature and oxygen content in the Bornholm basin in a) April b) late May/early June.

a)



a)



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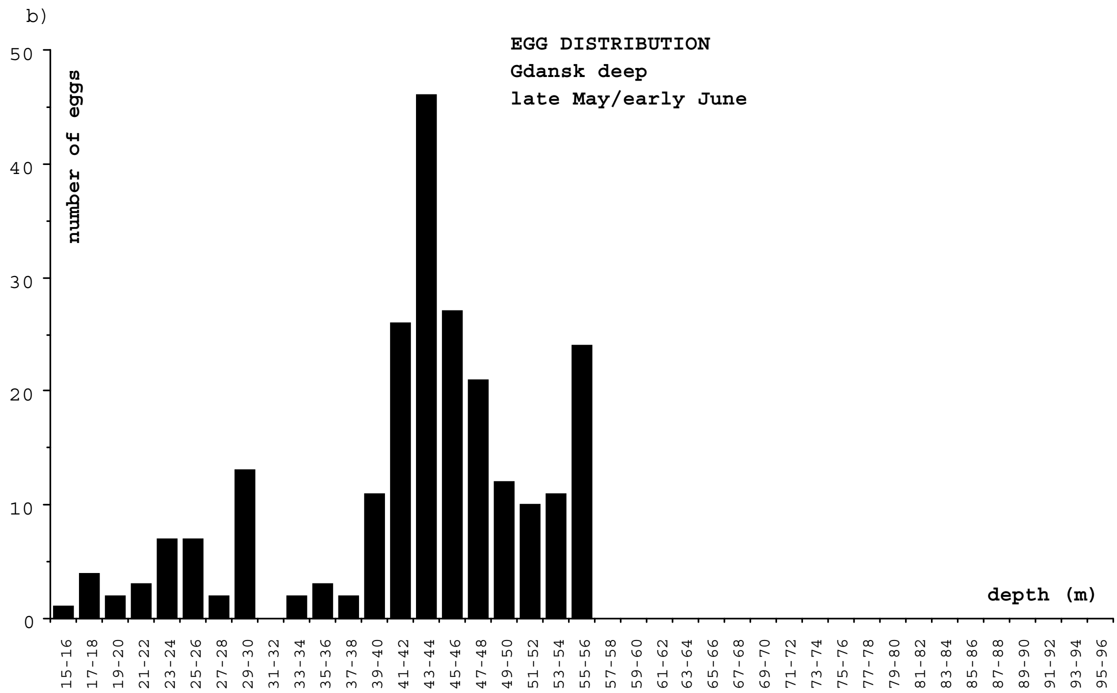

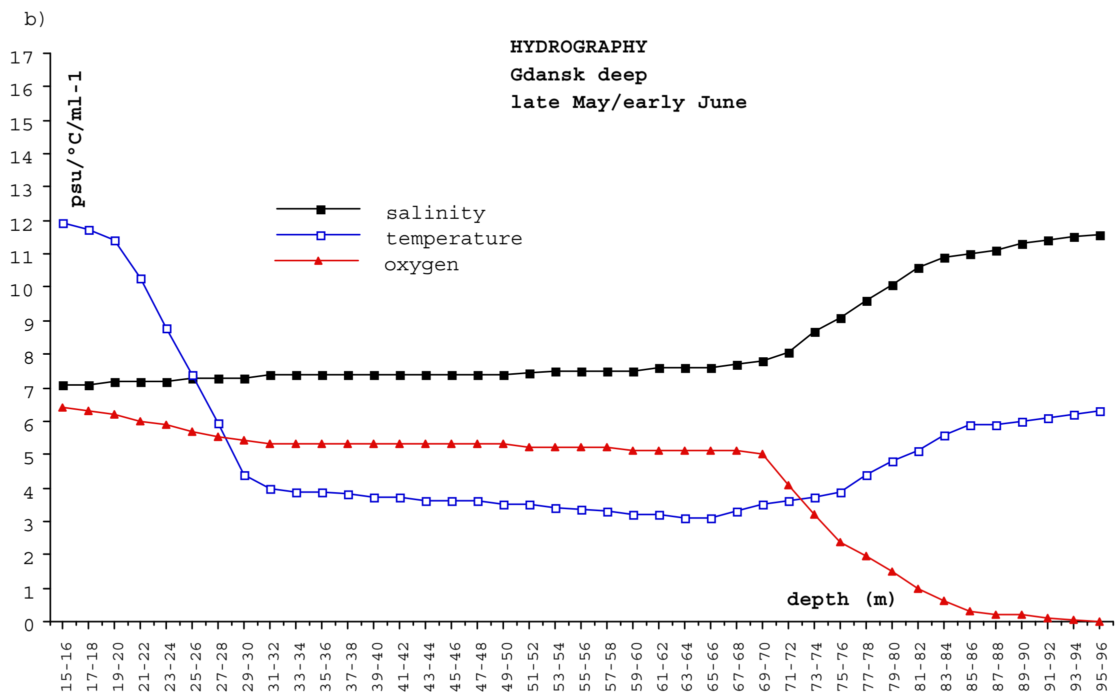

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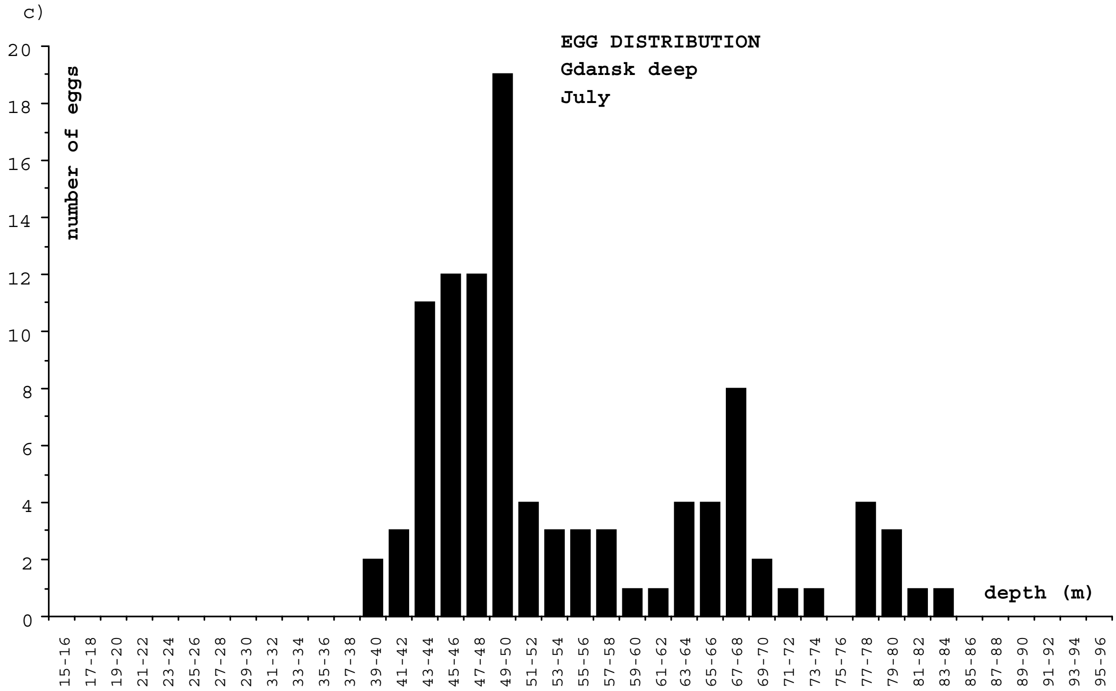


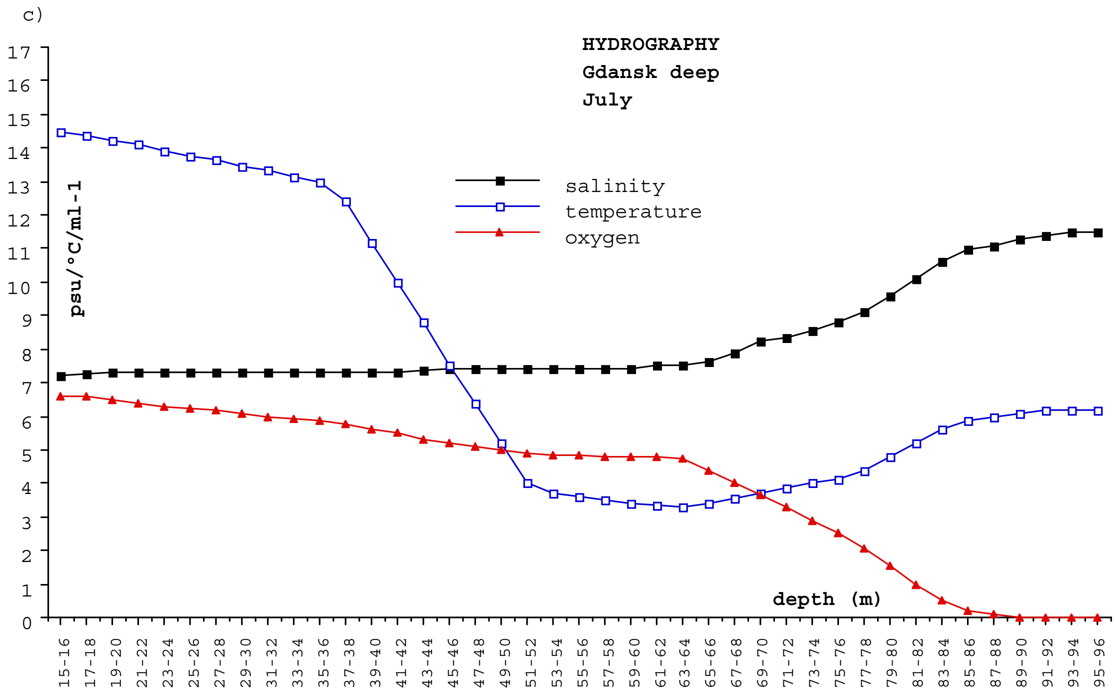
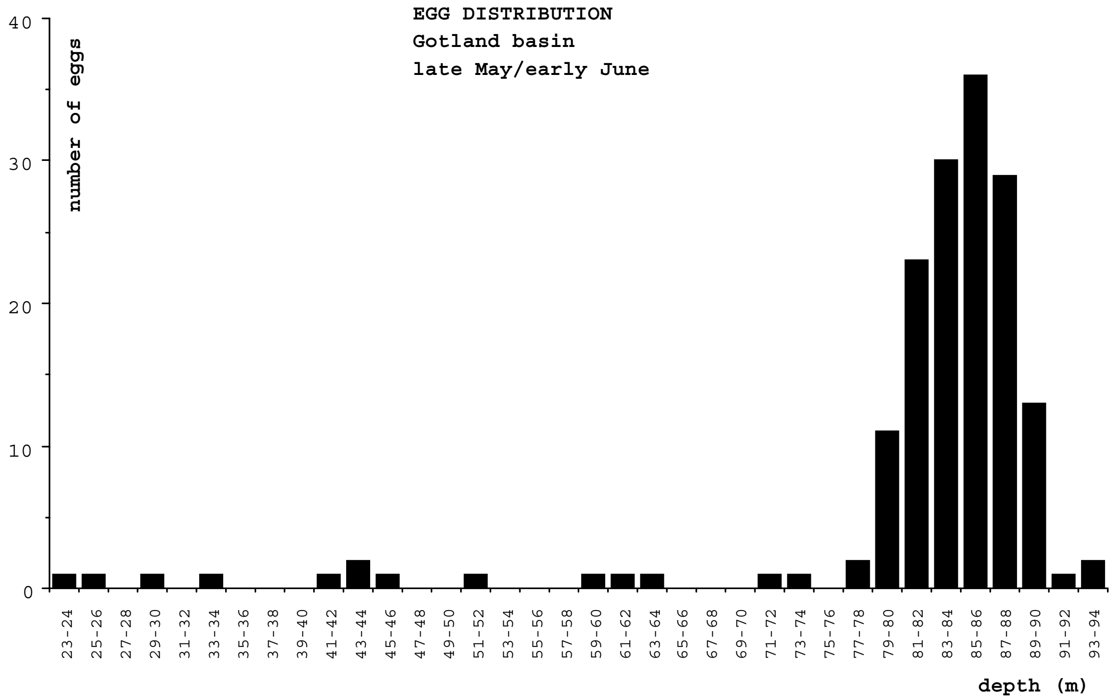


Fig. 2.2.8. Vertical distribution of sprat eggs and corresponding profiles of salinity, temperature and oxygen content in the Gdansk deep in a) April b) late May/early June and c) July.



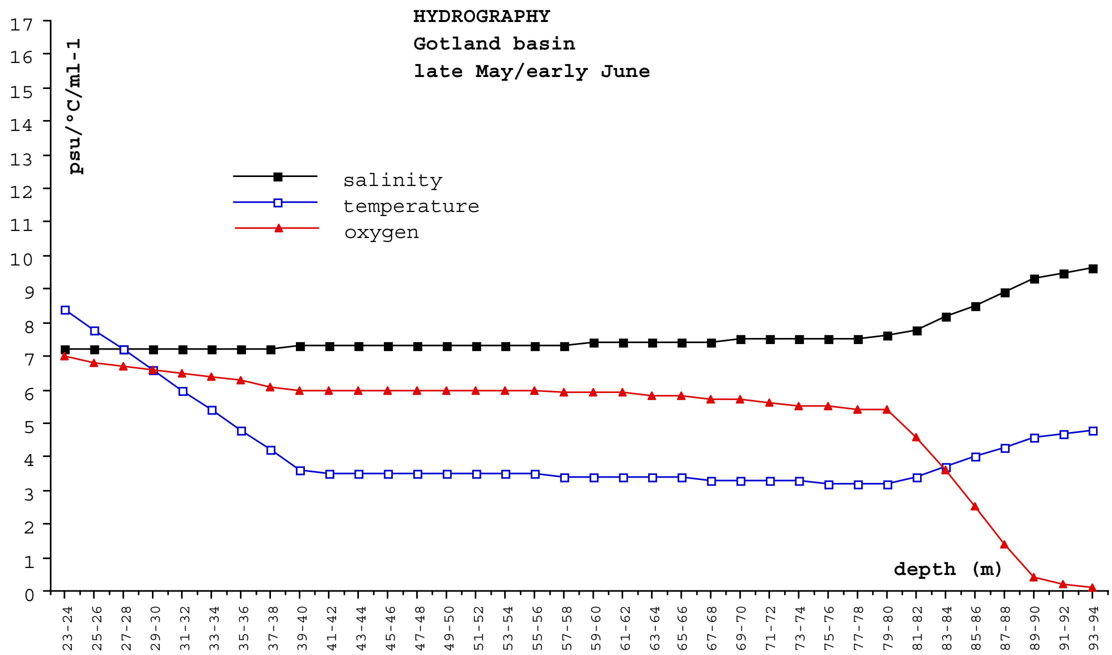
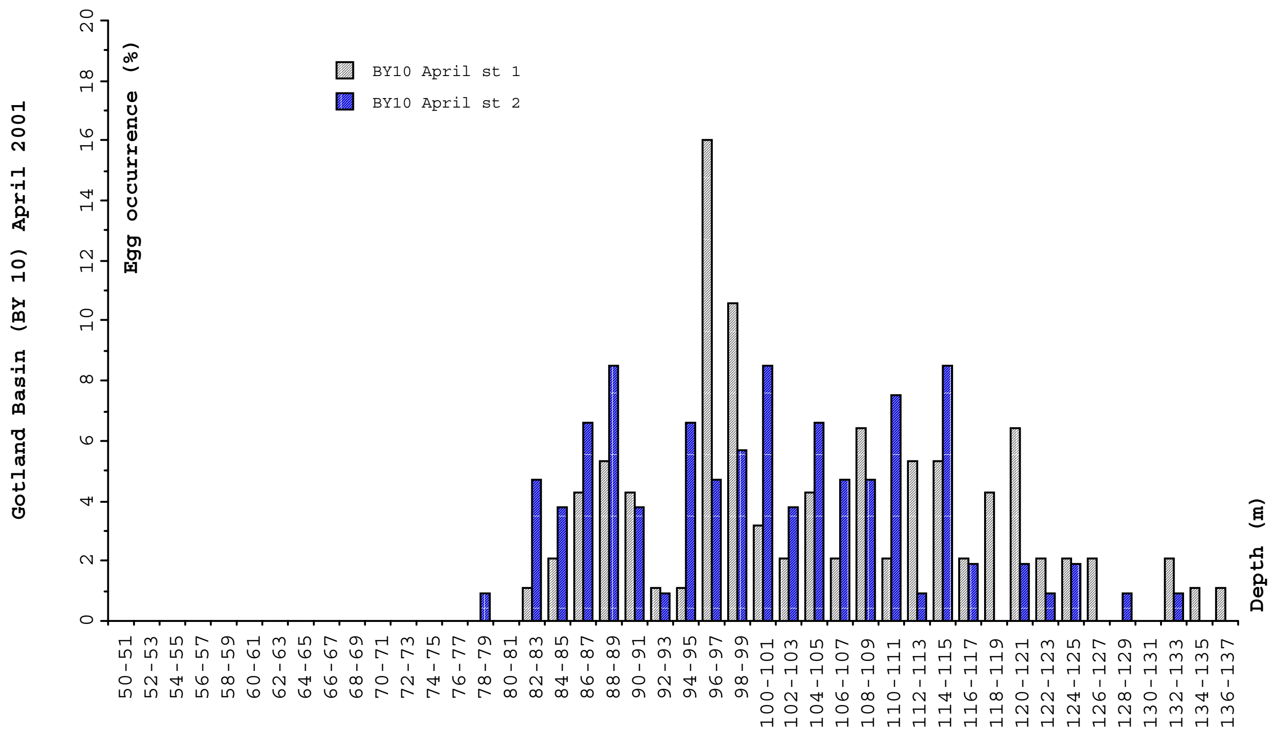
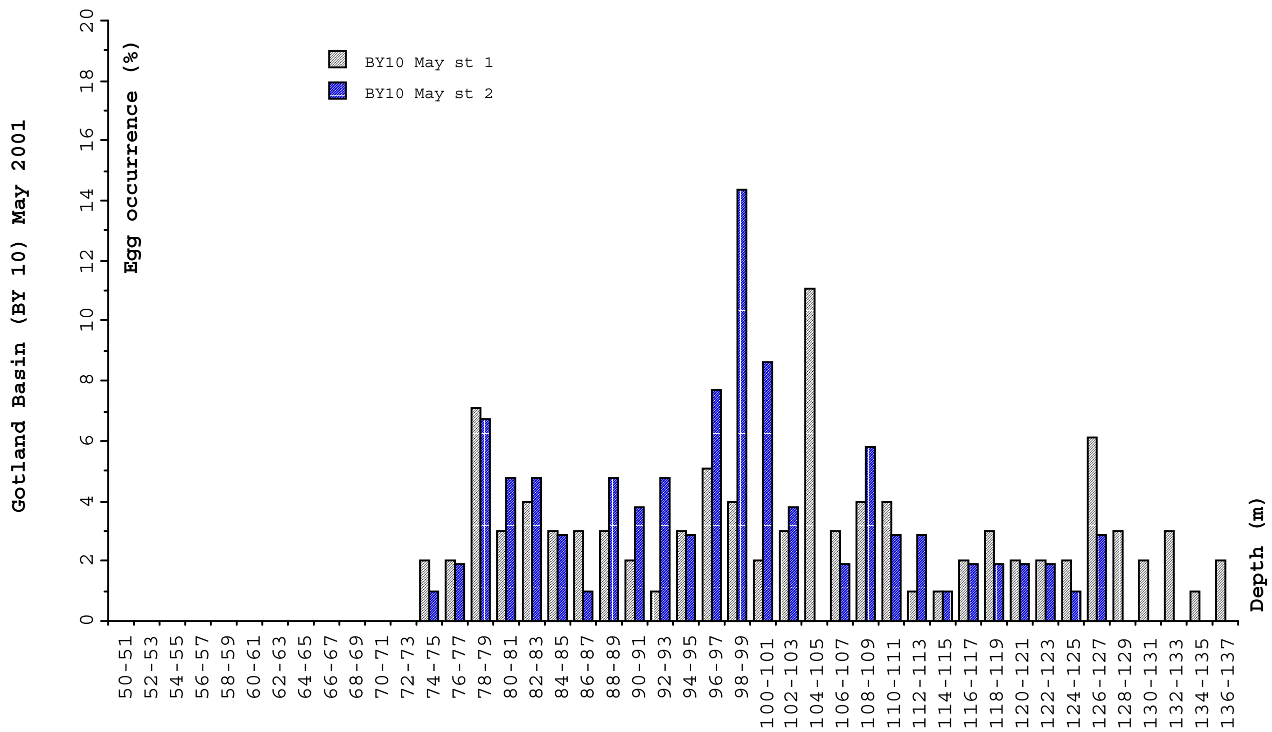


Fig. 2.2.9. Vertical distribution of sprat eggs and corresponding profiles of salinity, temperature and oxygen content in the Gotland basin in late May/early June.





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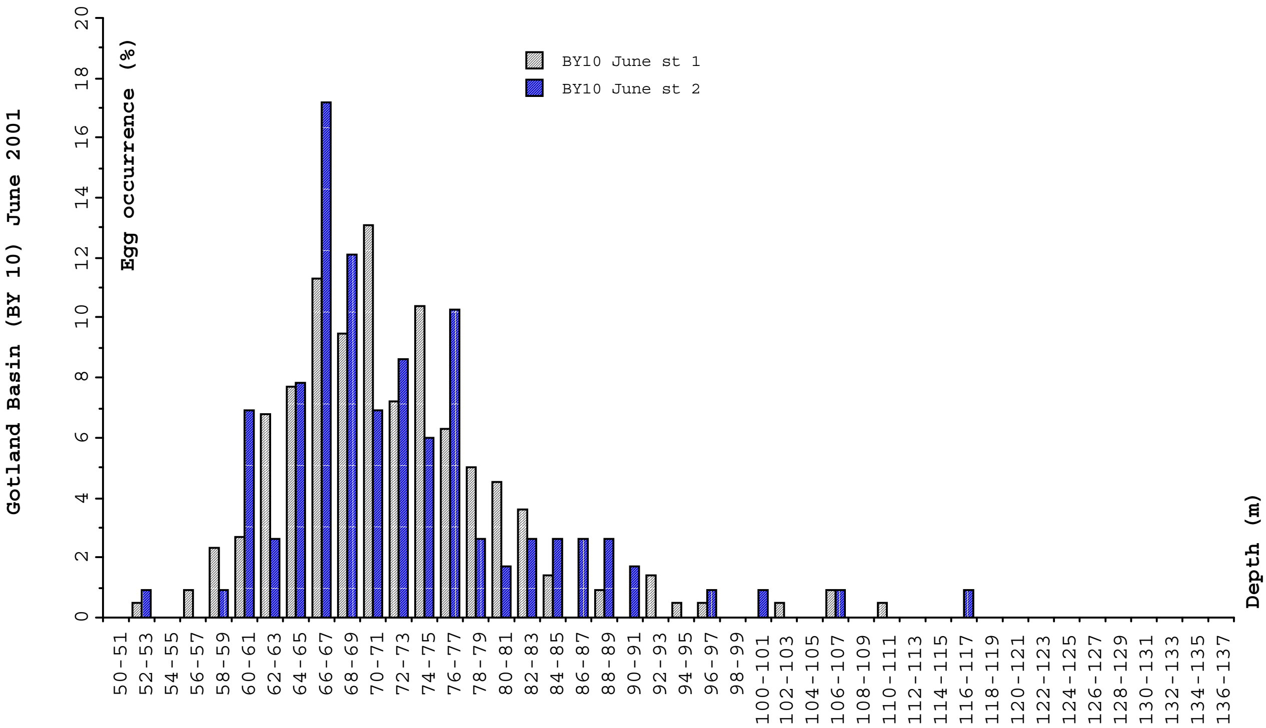

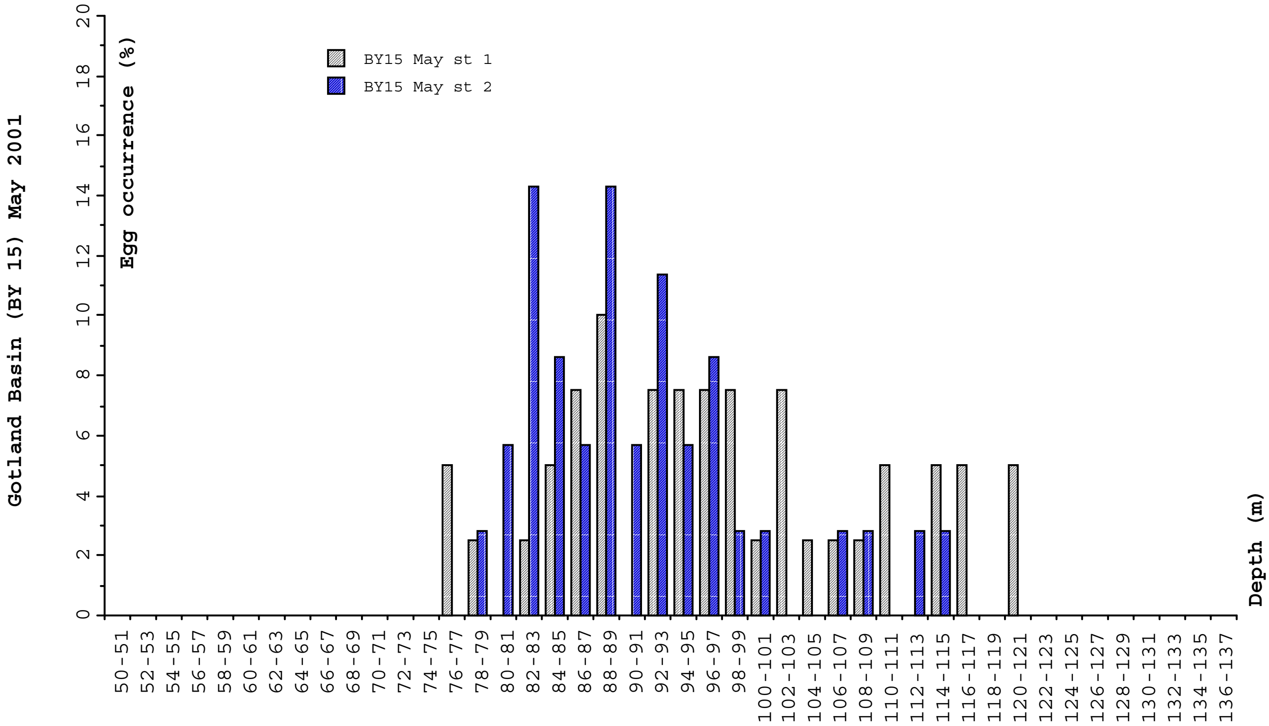

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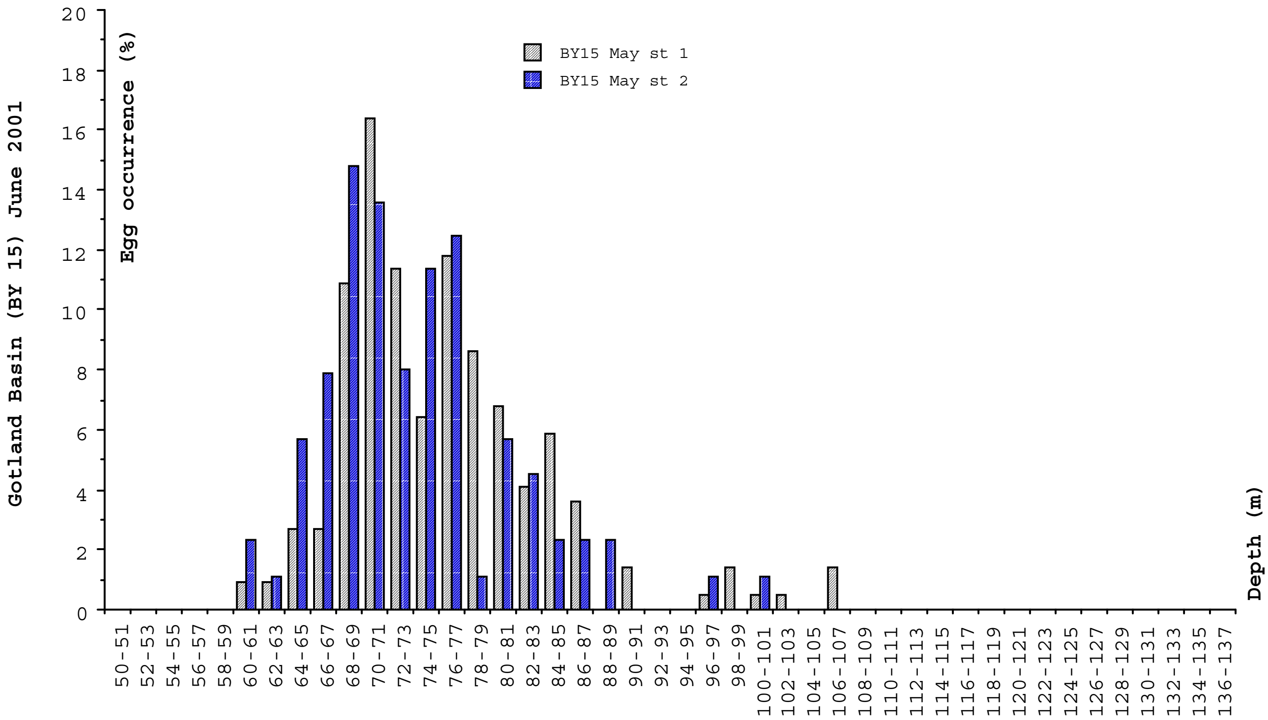
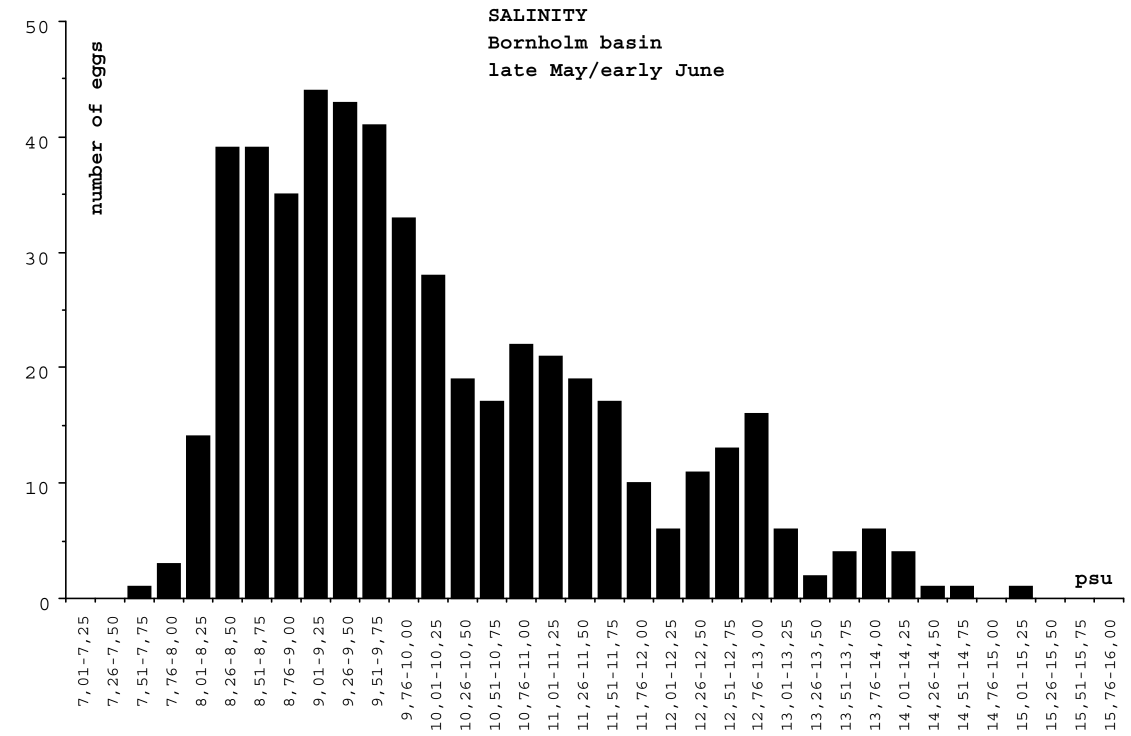
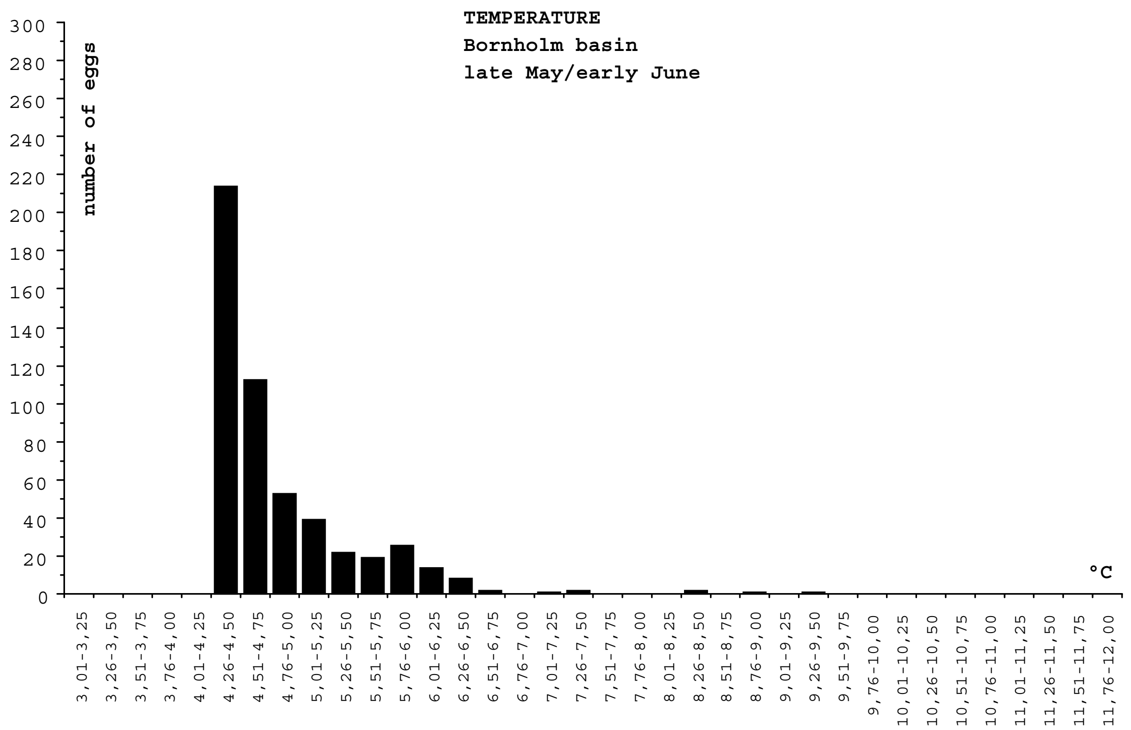
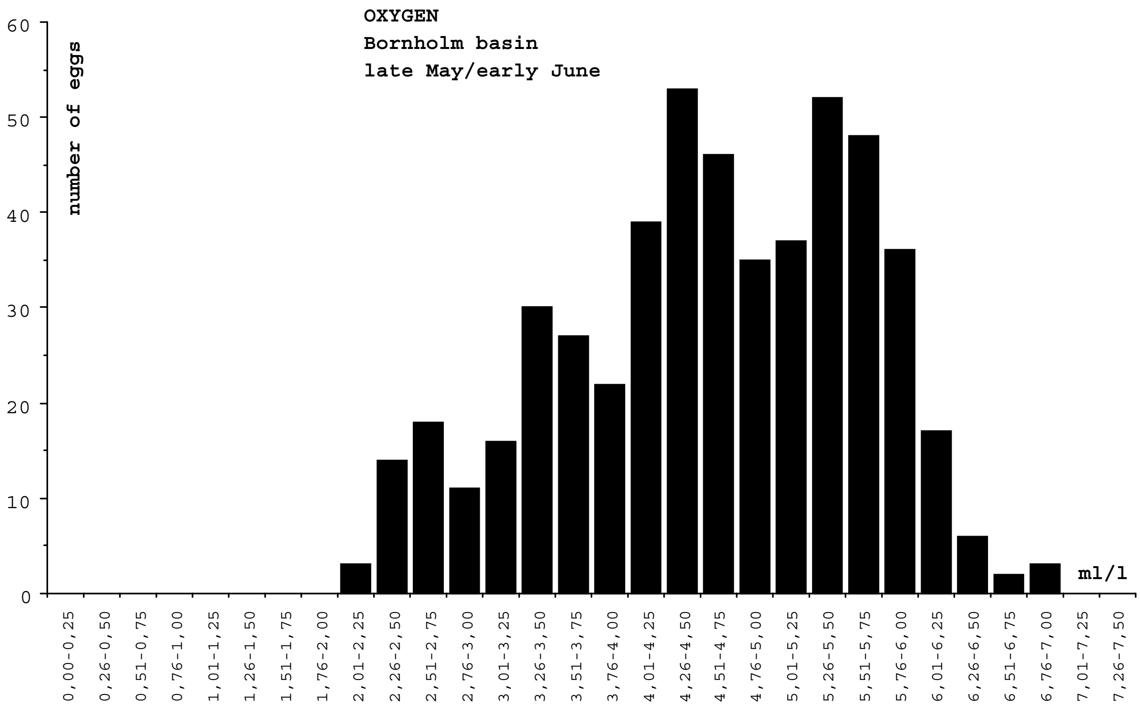


Figure 2.2.10. Vertical egg distributions of Baltic sprat from in situ sampling at two stations (BY 10 and By 15) in the Gotland Basin (SD 28) at different times during the spawning season in 2001.



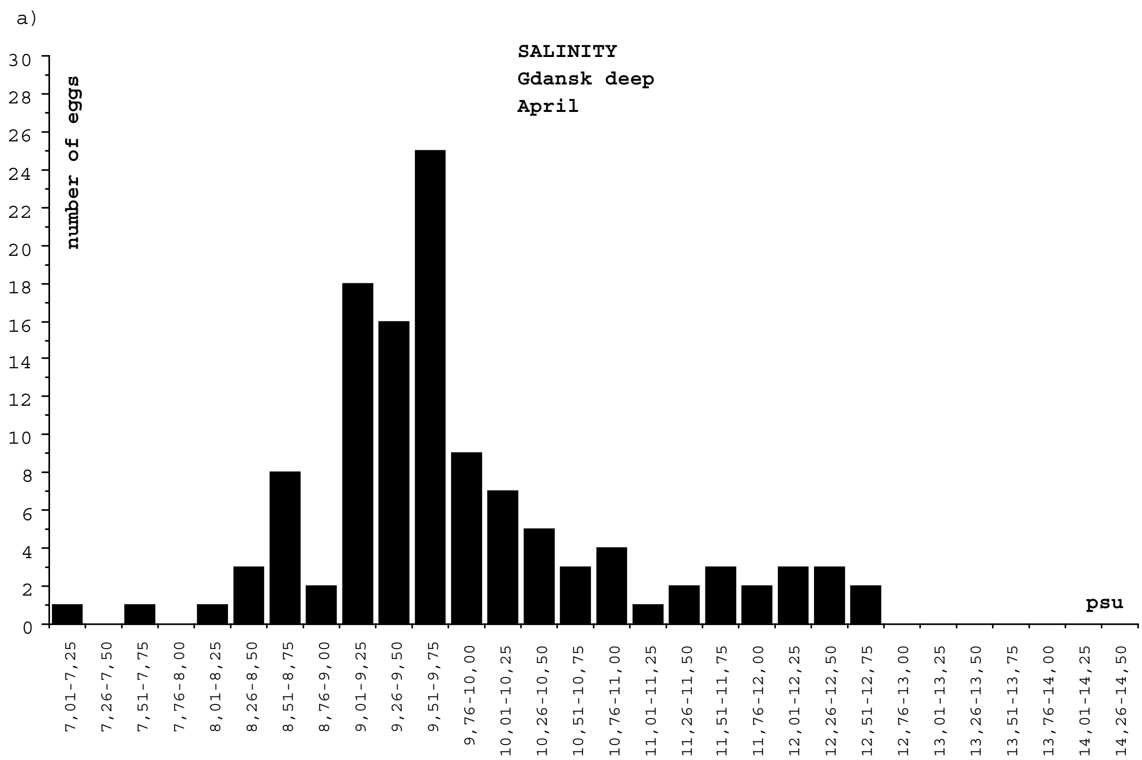


to be continued



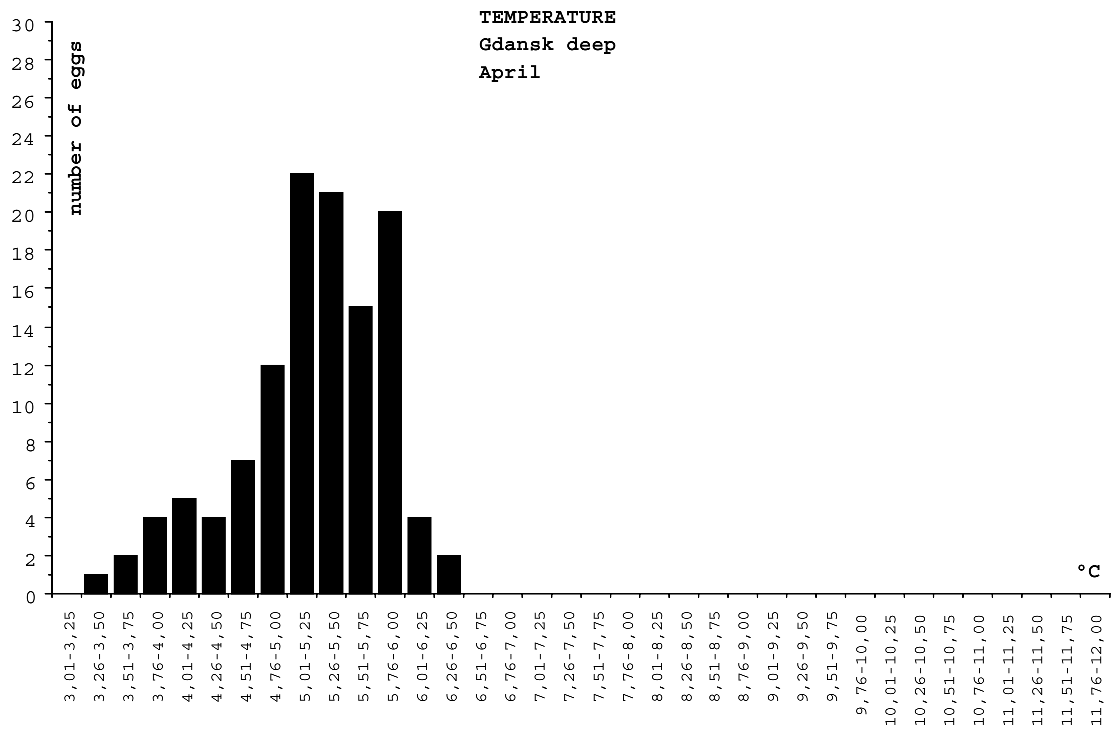
2.2.11. Distribution of sprat eggs in relation to salinity, temperature and oxygen concentration for eggs sampled in situ in the Bornholm basin in late May/early June.

a)

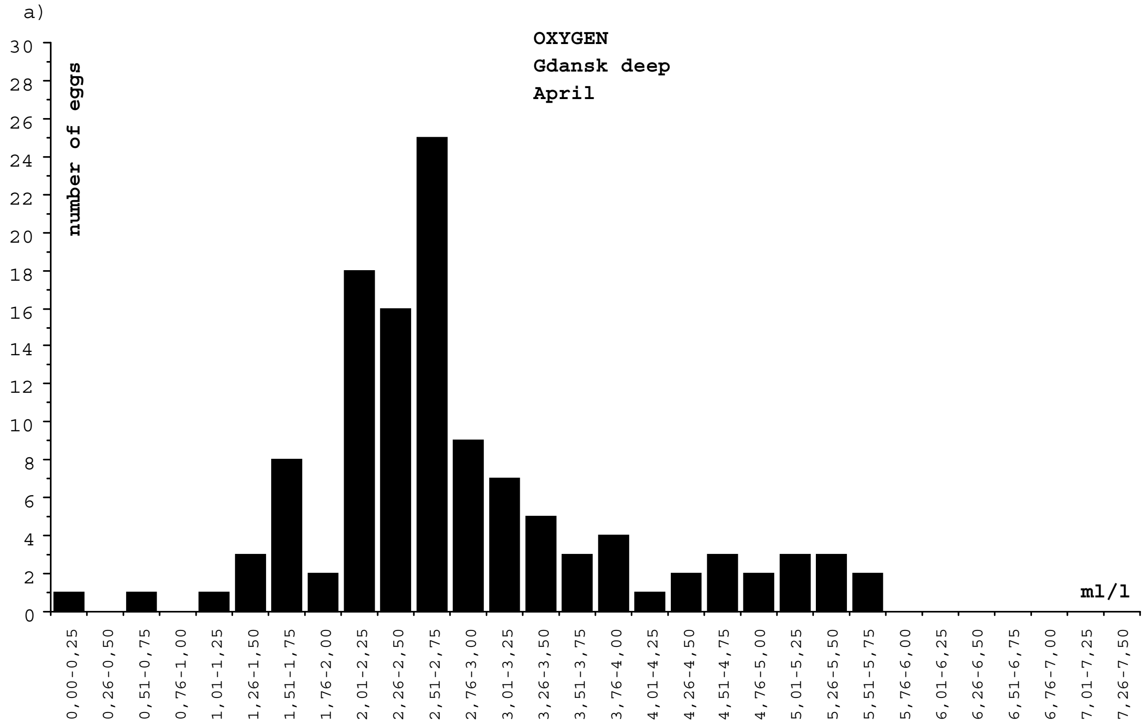


to be continued

a)



a)



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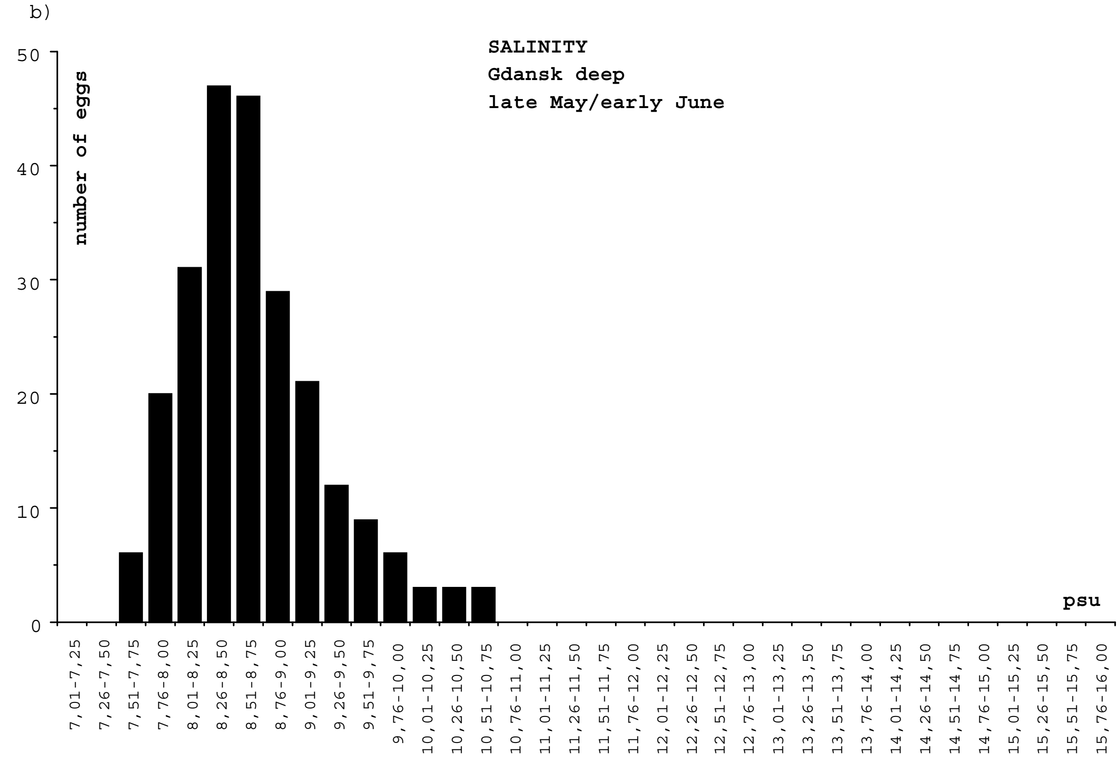
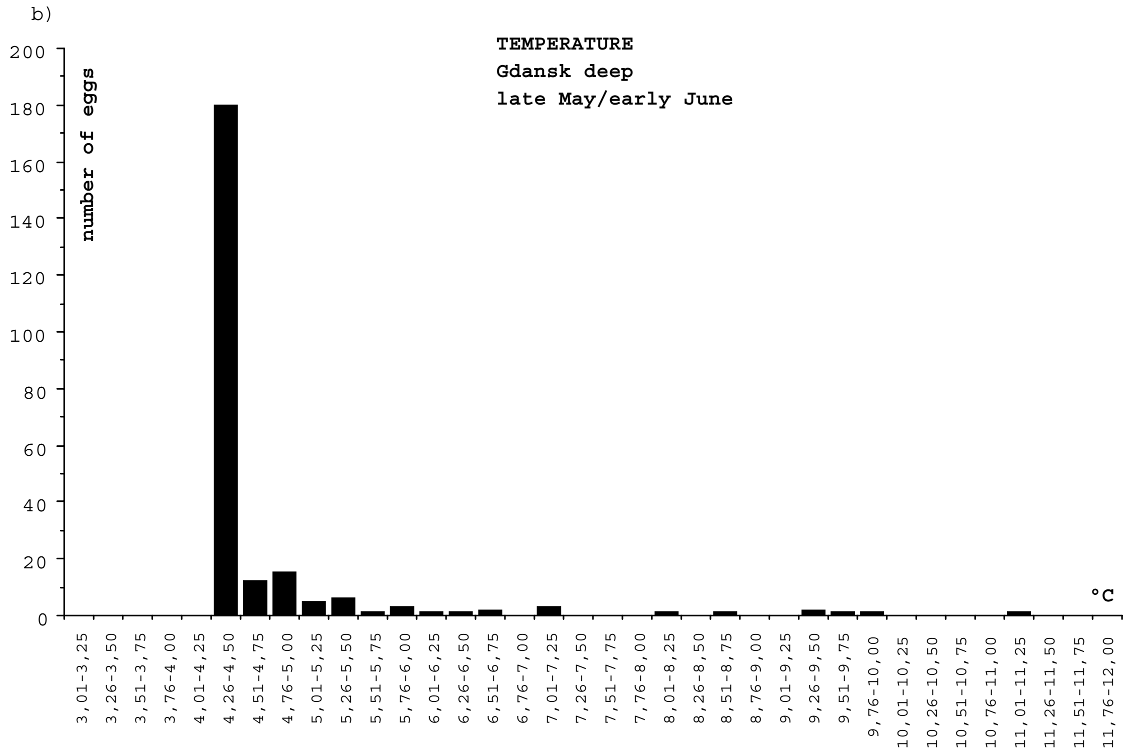
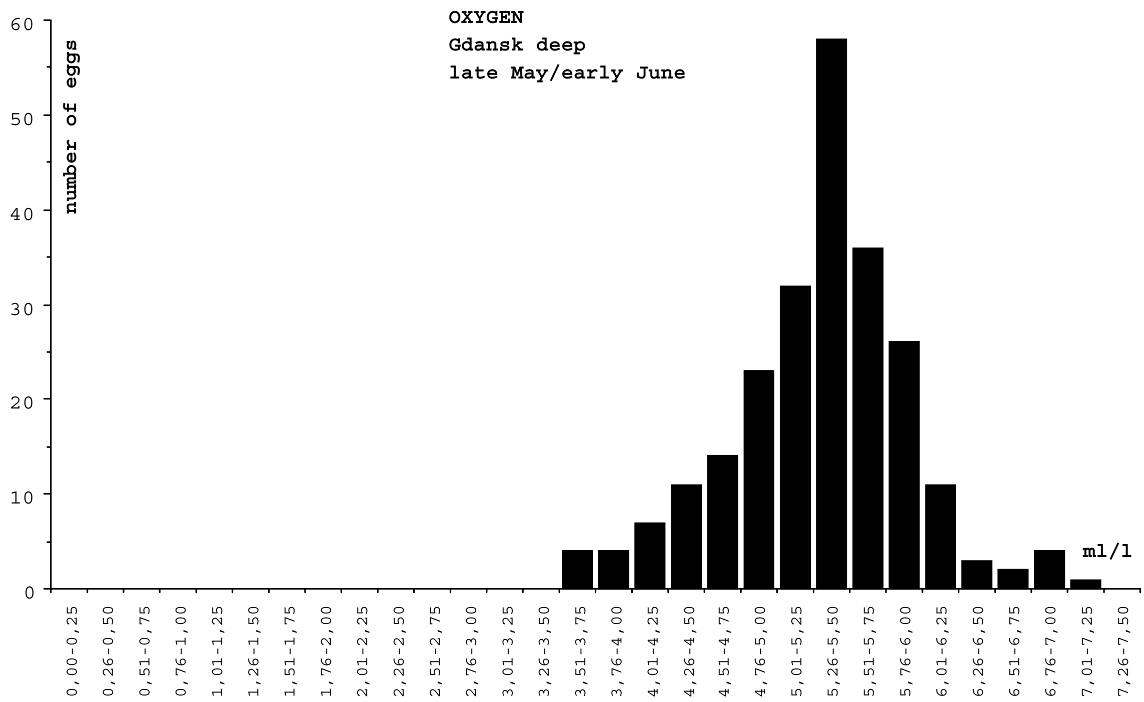


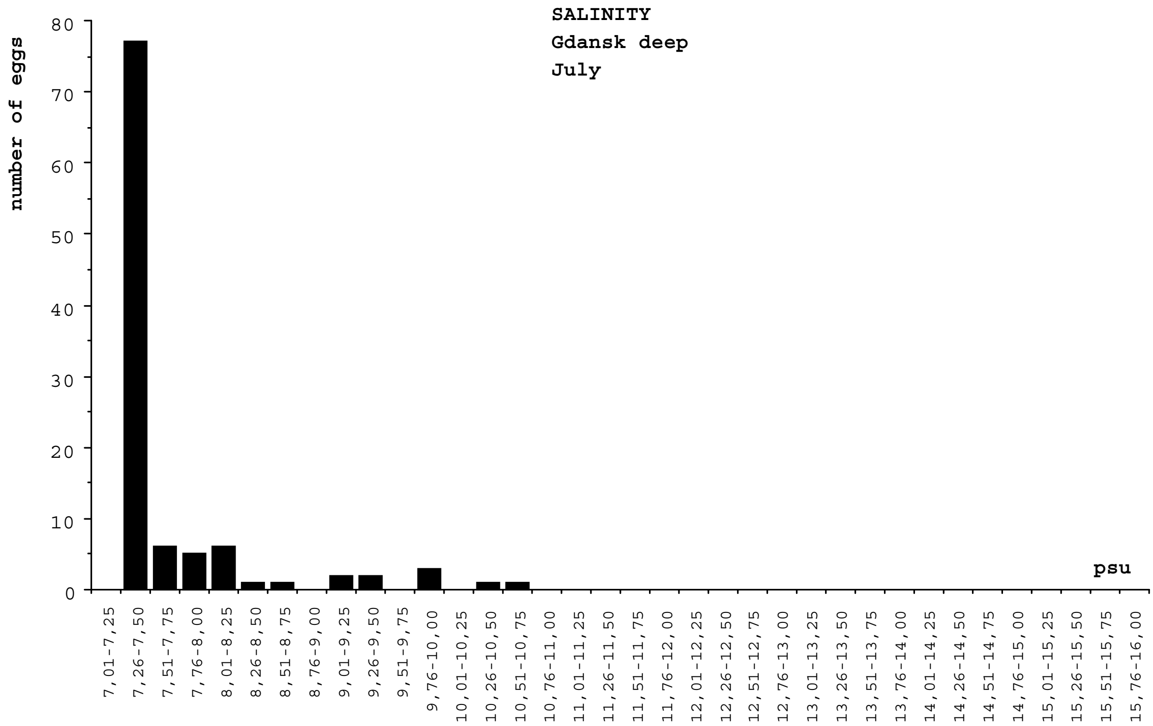


to be continued

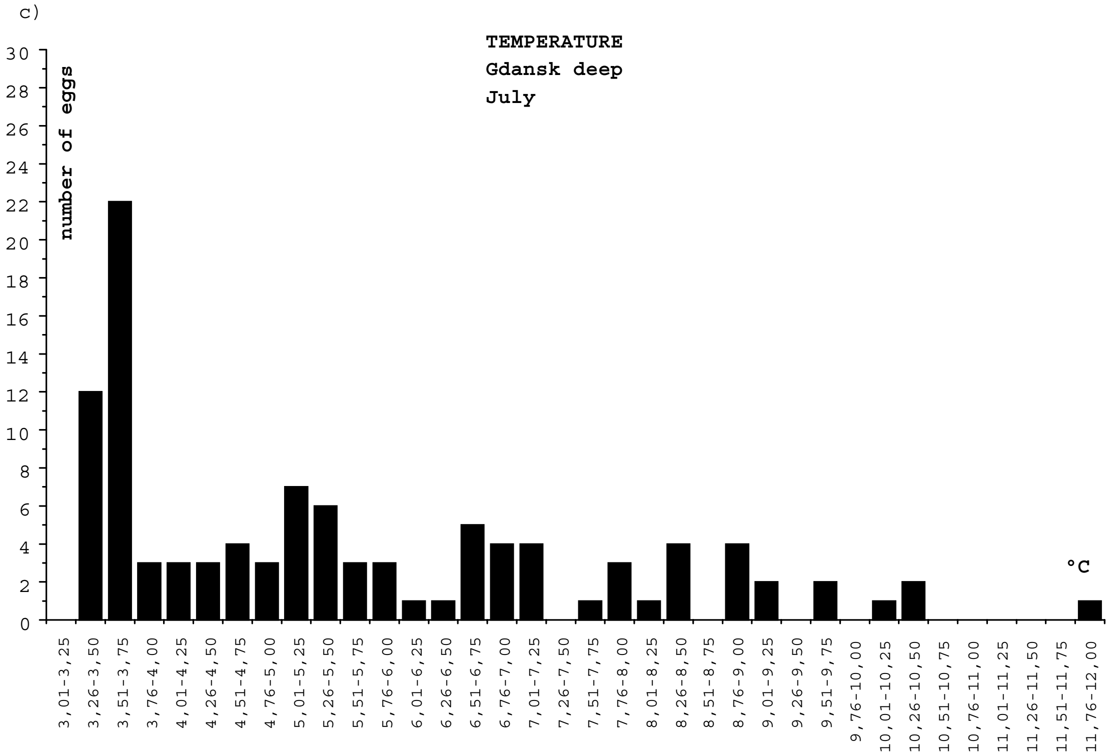
b)

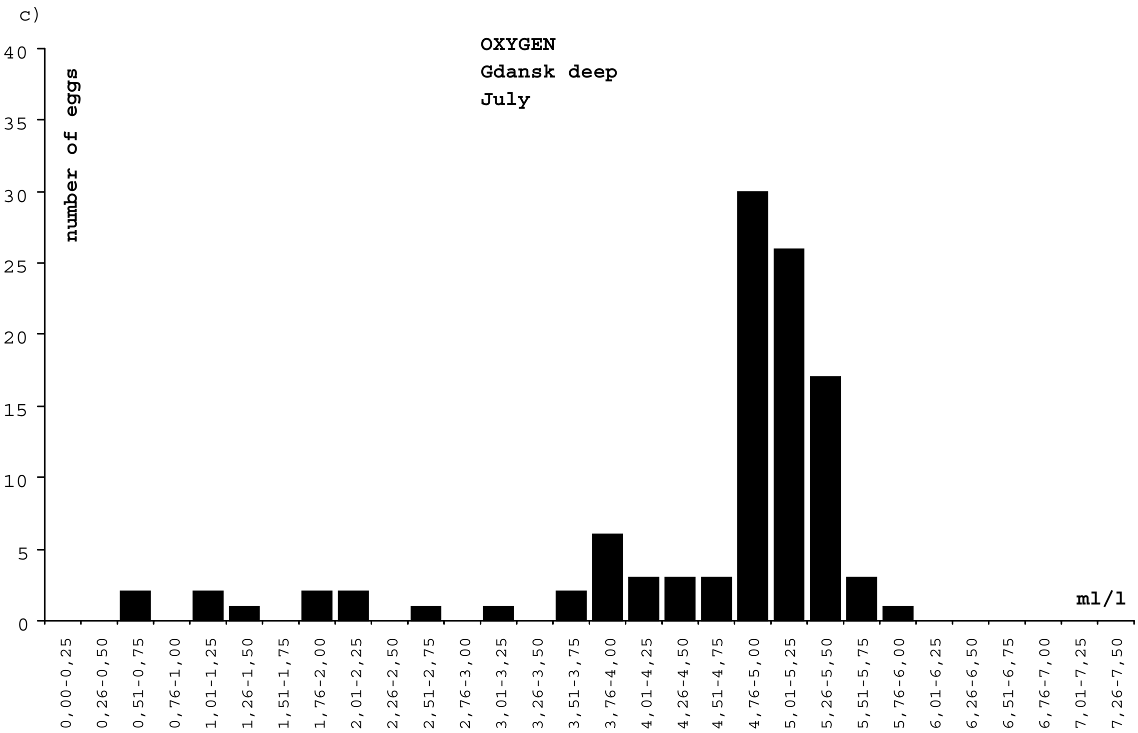


c)

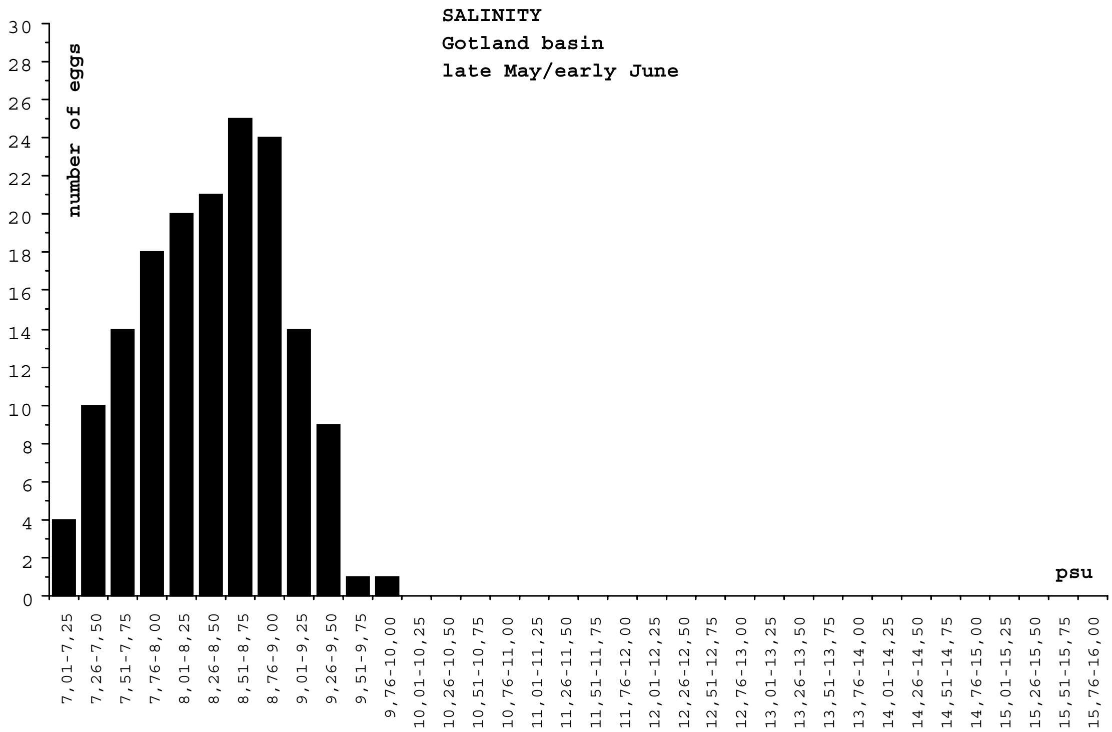


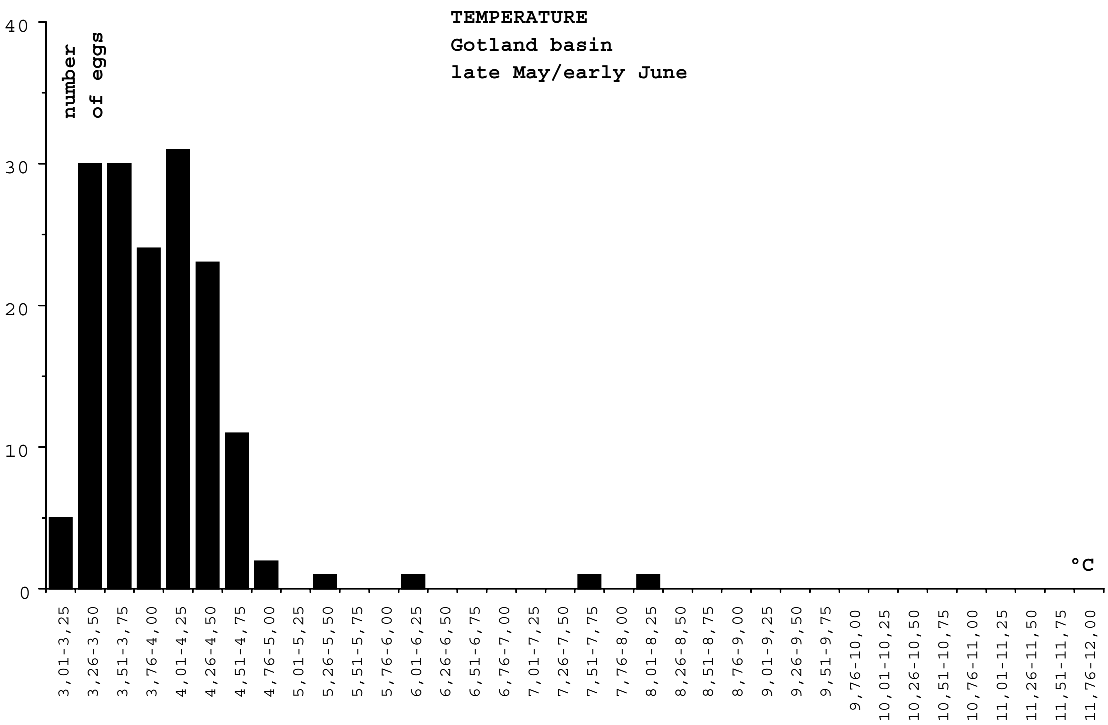
to be continued

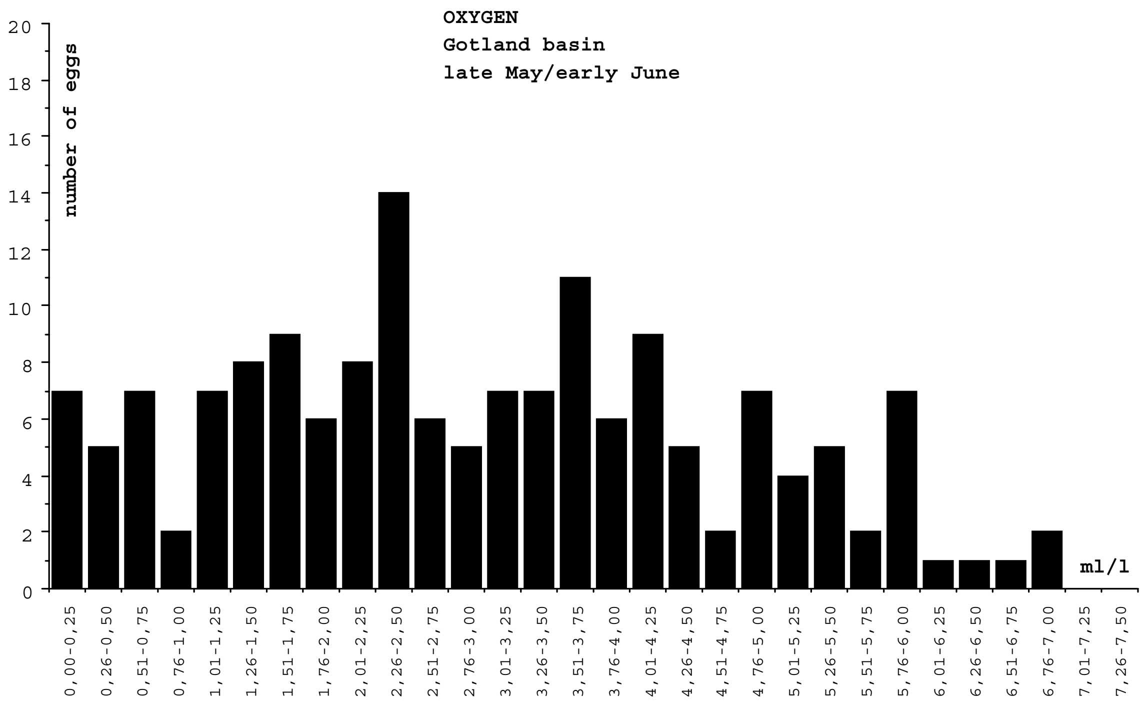




2.2.12. Distribution of sprat eggs in relation to salinity, temperature and oxygen concentration for eggs sampled in situ in the Gdansk deep in a) April b) late May/early June and c) July.

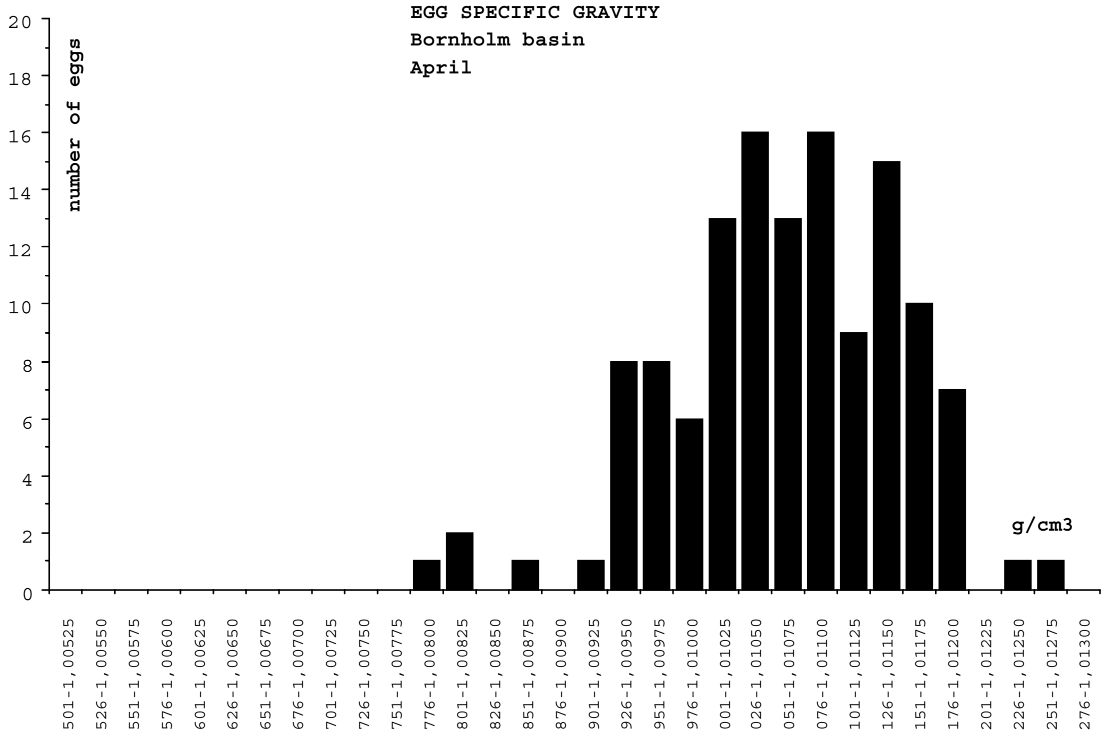

SALINITY
Gotland basin
late May/early June
number of eggs
psu


TEMPERATURE
Gotland basin
late May/early June
number of eggs
°C

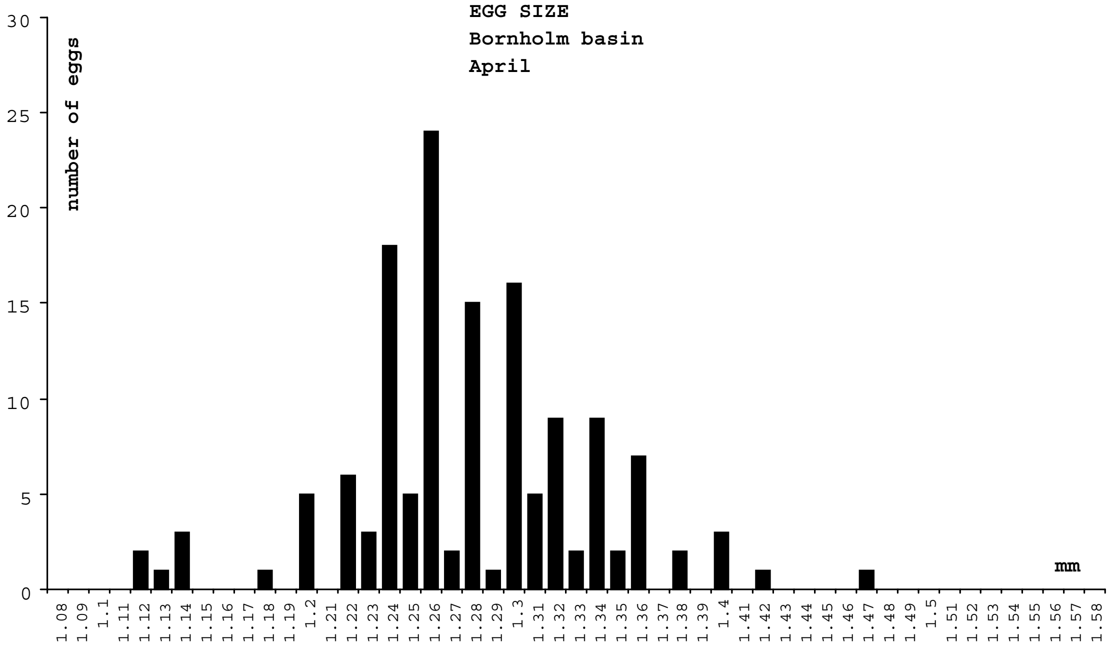


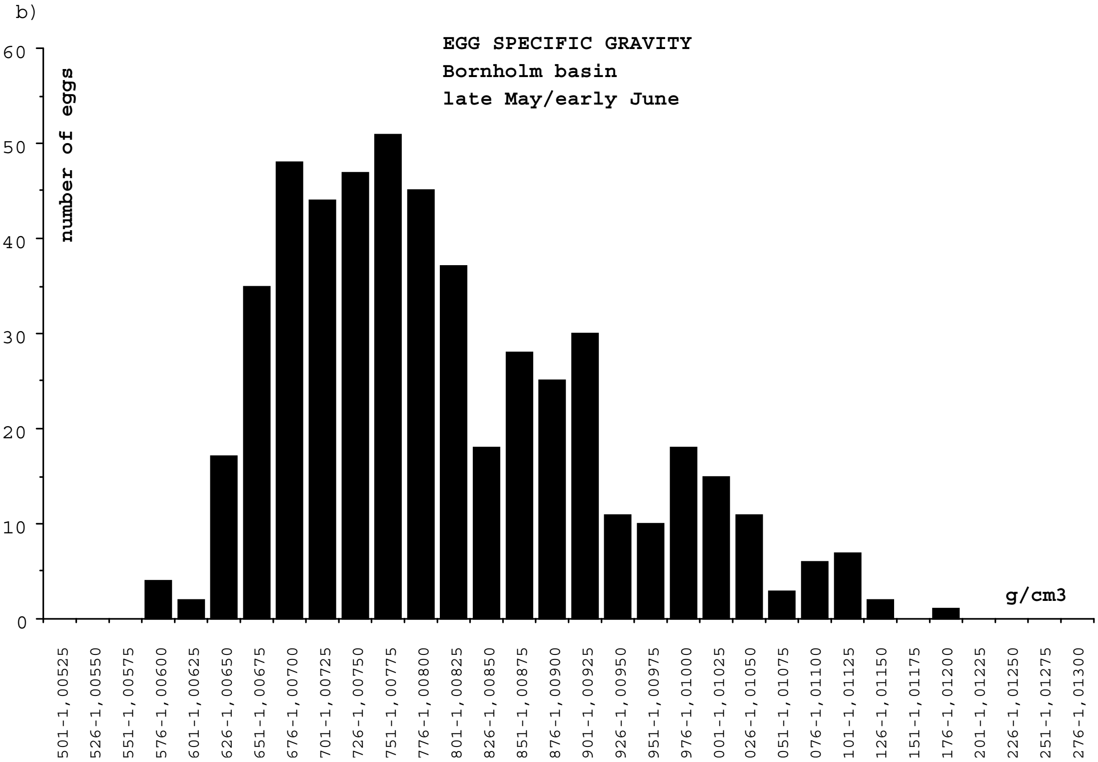
2.2.13. Distribution of sprat eggs in relation to salinity, temperature and oxygen concentration for eggs sampled in situ in the Gotland basin in late May/early June.

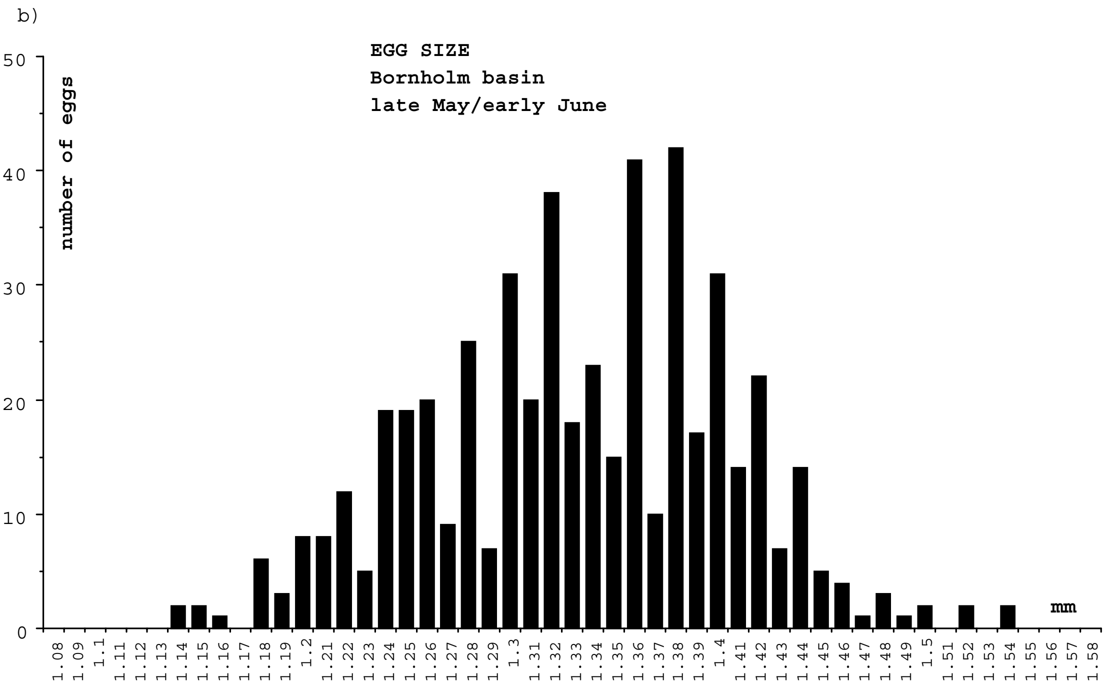
a)


EGG SPECIFIC GRAVITY
Bornholm basin
April
number of eggs
g/cm3

a)

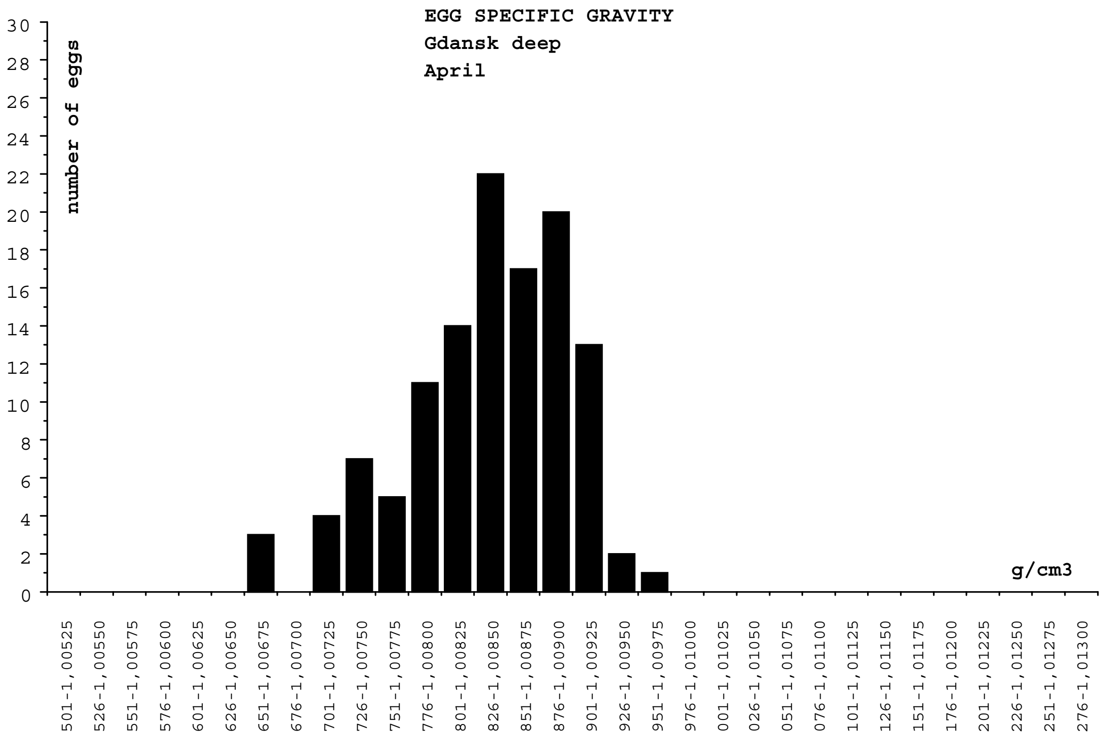

EGG SIZE
Bornholm basin
April
number of eggs
mm



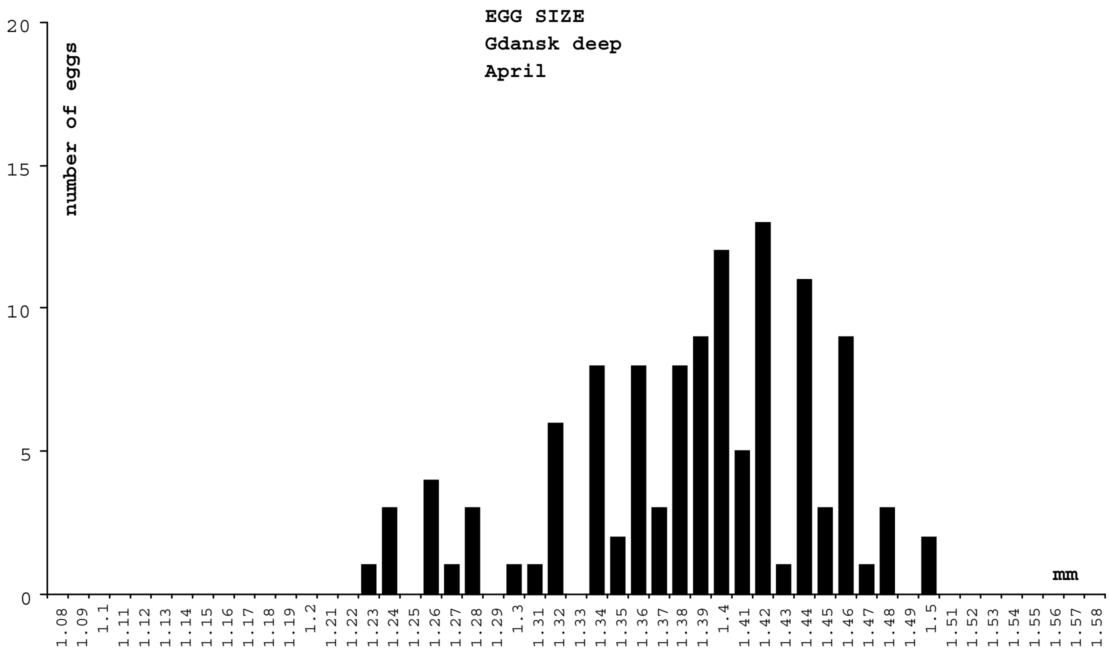


2.2.14. Egg specific gravity and egg size (preserved eggs) of in situ sampled sprat eggs from the Bornholm basin in a) April b) late May/early June.

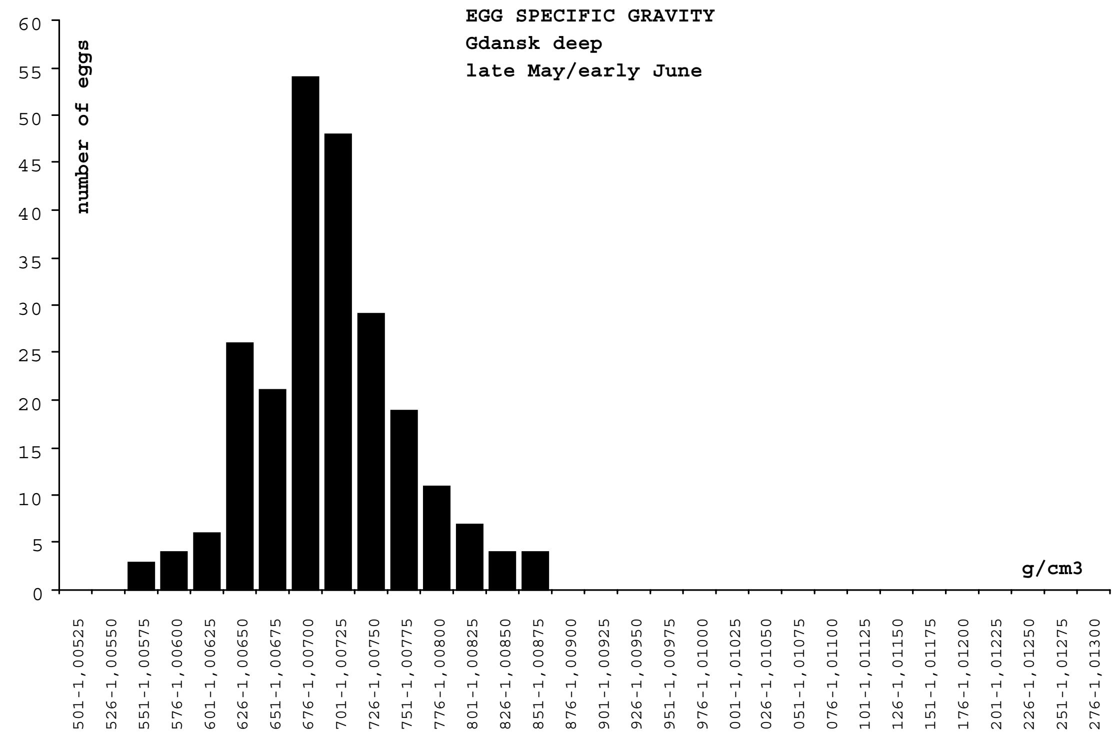
a)


EGG SPECIFIC GRAVITY
Gdansk deep
April
number of eggs
g/cm3
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30
501-1,00525 526-1,00550 551-1,00575 576-1,00600 601-1,00625 626-1,00650 651-1,00675 676-1,00700 701-1,00725 726-1,00750 751-1,00775 776-1,00800 801-1,00825 826-1,00850 851-1,00875 876-1,00900 901-1,00925 926-1,00950 951-1,00975 976-1,01000 001-1,01025 026-1,01050 051-1,01075 076-1,01100 101-1,01125 126-1,01150 151-1,01175 176-1,01200 201-1,01225 226-1,01250 251-1,01275 276-1,01300

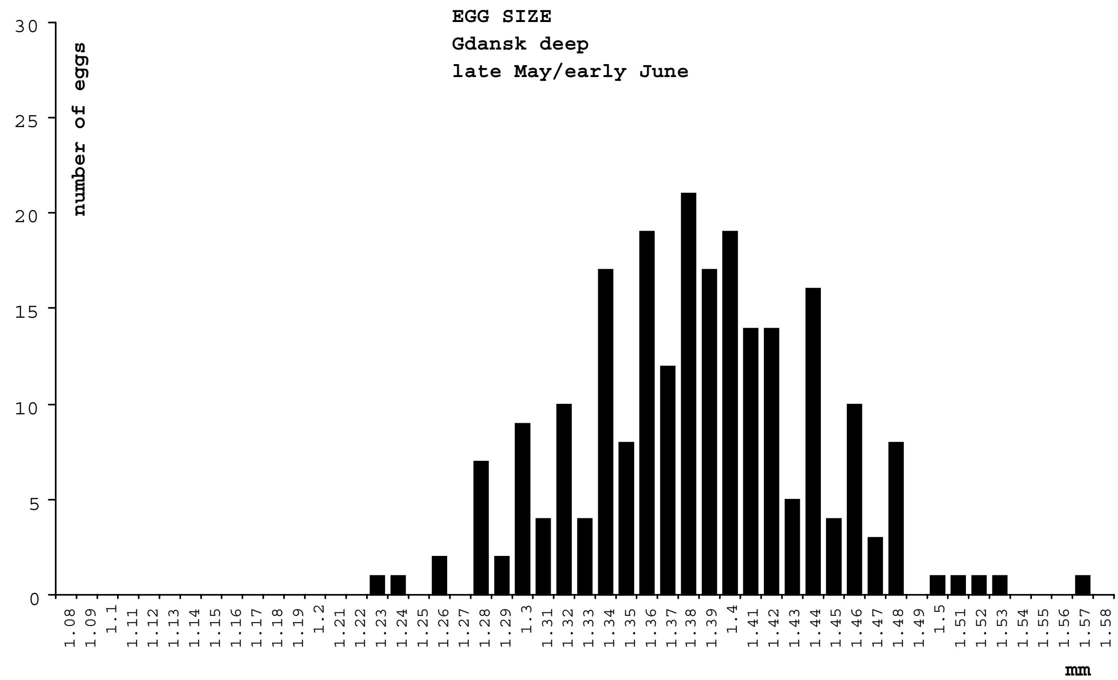
a)

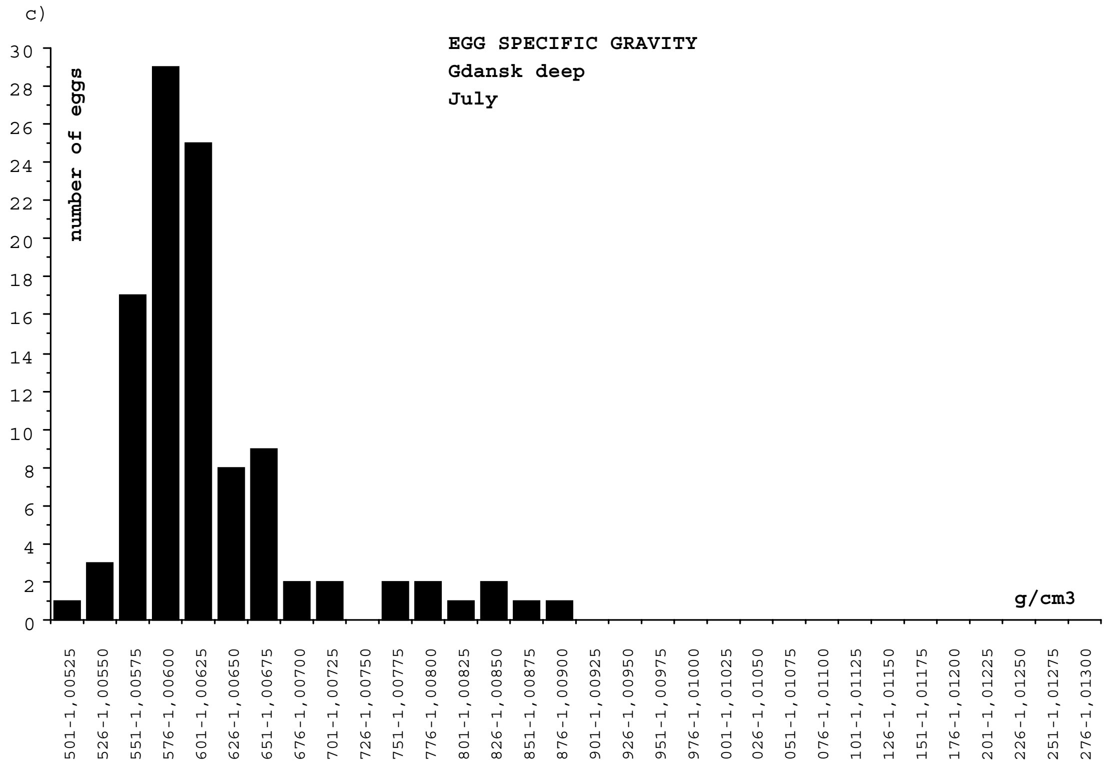

EGG SIZE
Gdansk deep
April
number of eggs
mm
0 5 10 15 20
1.08 1.09 1.1 1.11 1.12 1.13 1.14 1.15 1.16 1.17 1.18 1.19 1.2 1.21 1.22 1.23 1.24 1.25 1.26 1.27 1.28 1.29 1.3 1.31 1.32 1.33 1.34 1.35 1.36 1.37 1.38 1.39 1.4 1.41 1.42 1.43 1.44 1.45 1.46 1.47 1.48 1.49 1.5 1.51 1.52 1.53 1.54 1.55 1.56 1.57 1.58

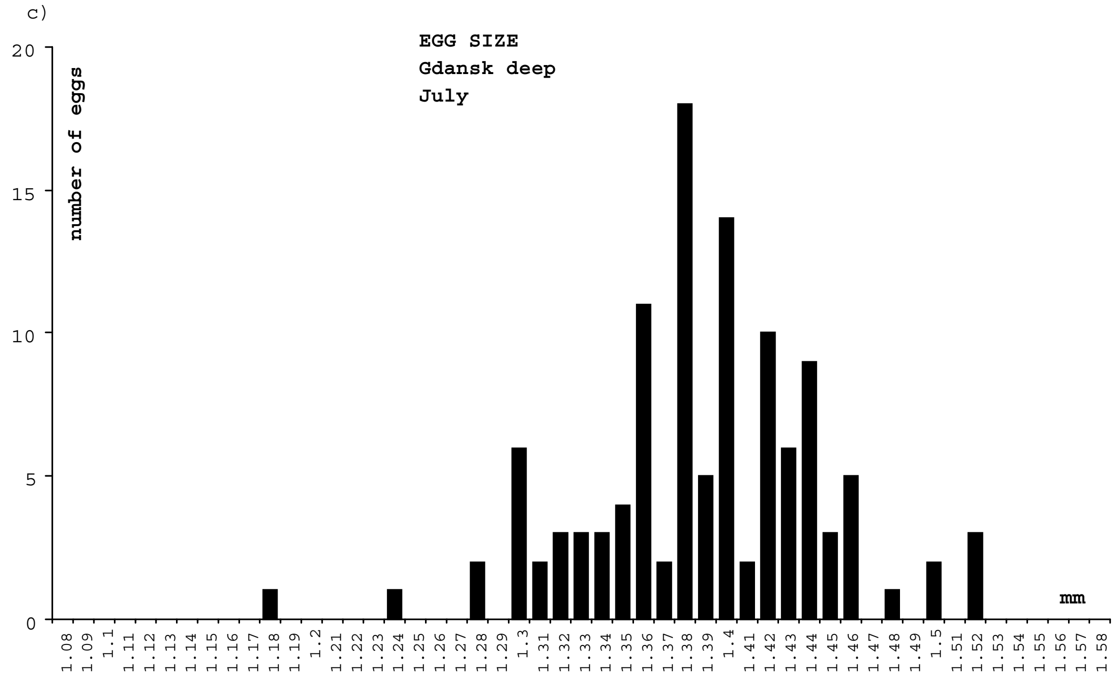
b)


EGG SPECIFIC GRAVITY
Gdansk deep
late May/early June
number of eggs
g/cm3

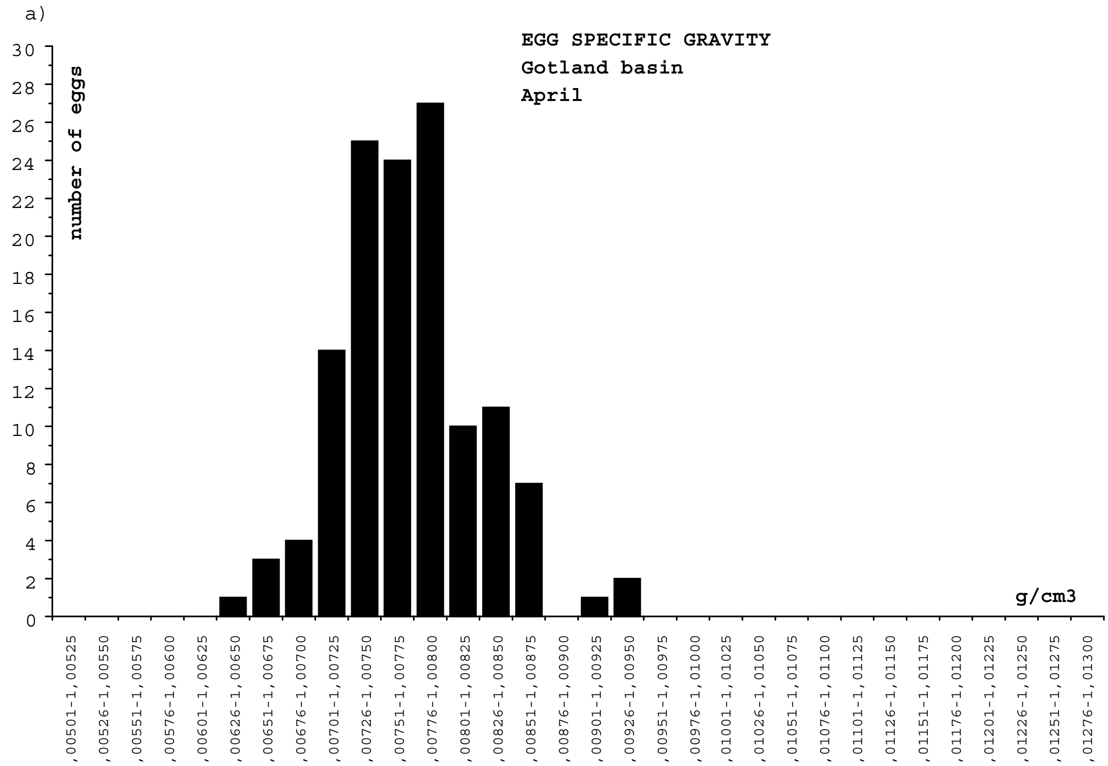
b)

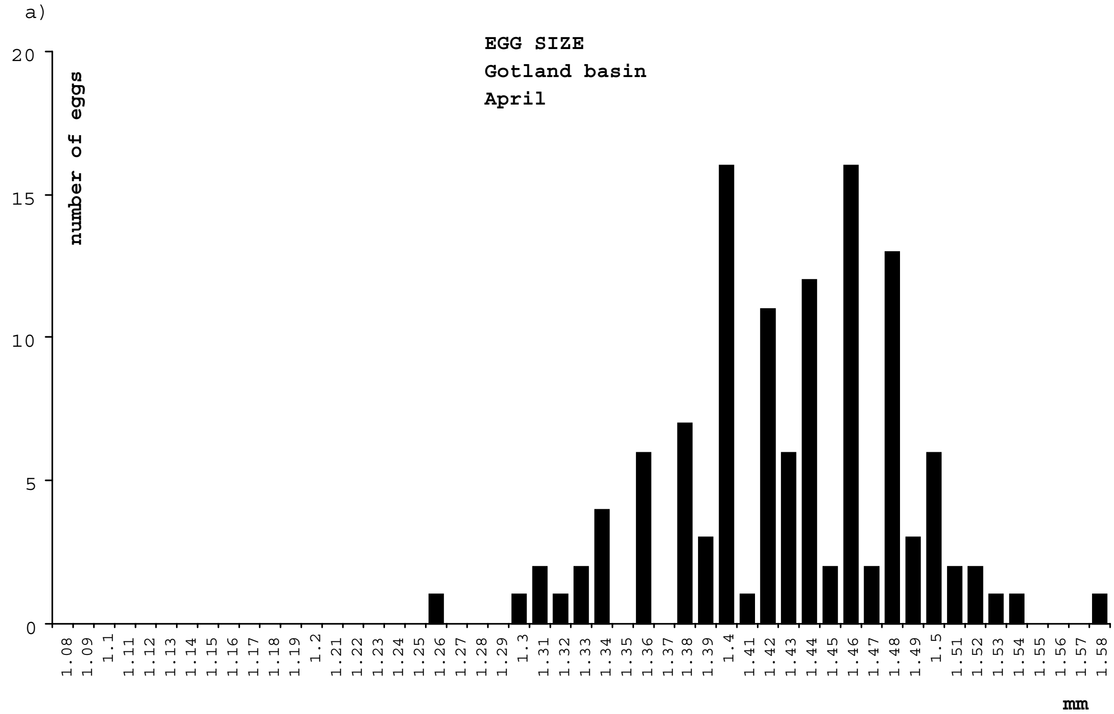

EGG SIZE
Gdansk deep
late May/early June
number of eggs
mm

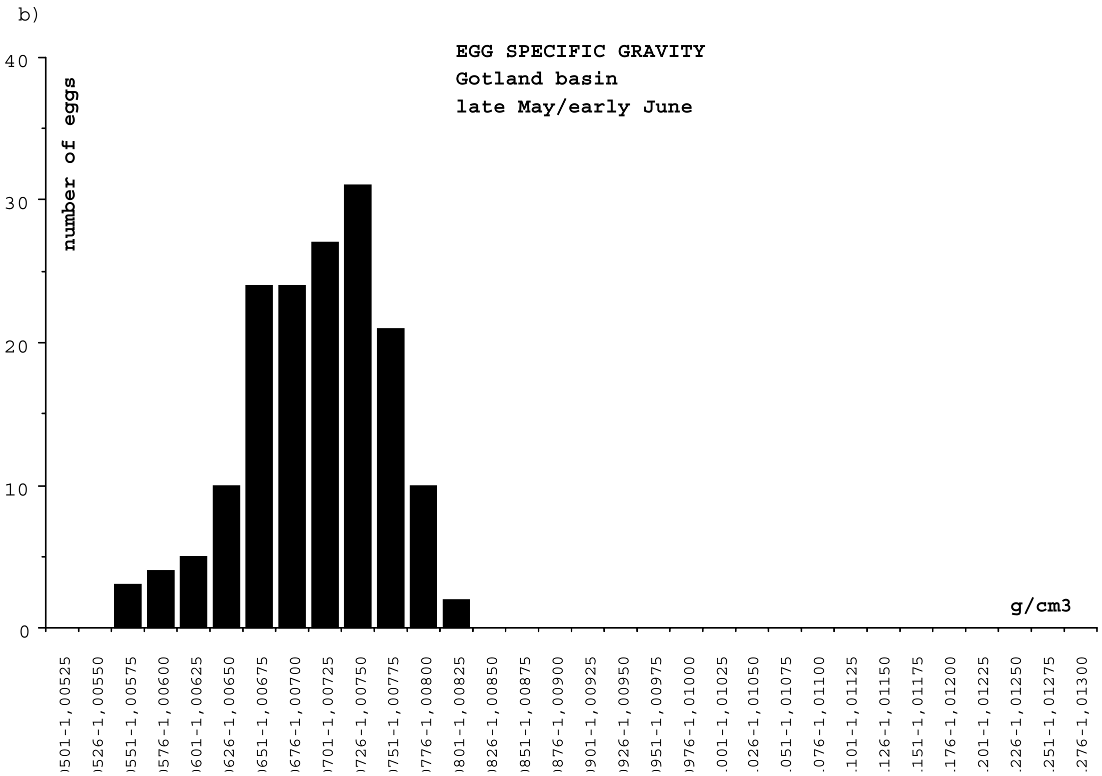


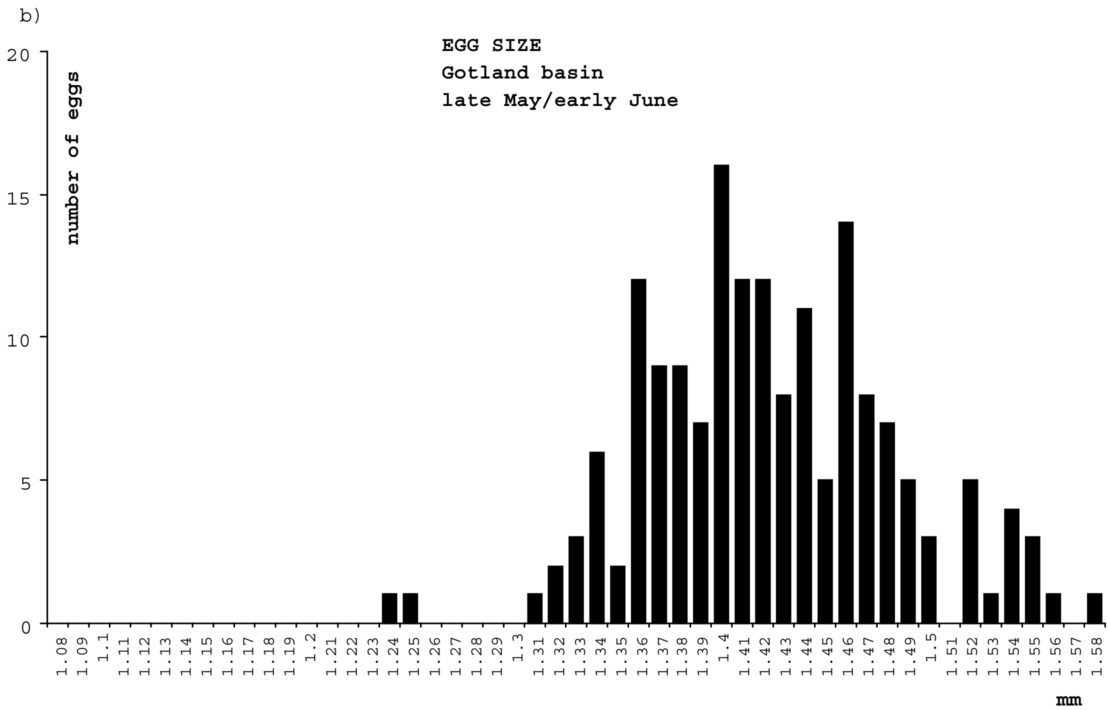


2.2.15. Egg specific gravity and egg size (preserved eggs) of in situ sampled sprat eggs from the Gdansk deep in a) April b) late May/early June and c) July.

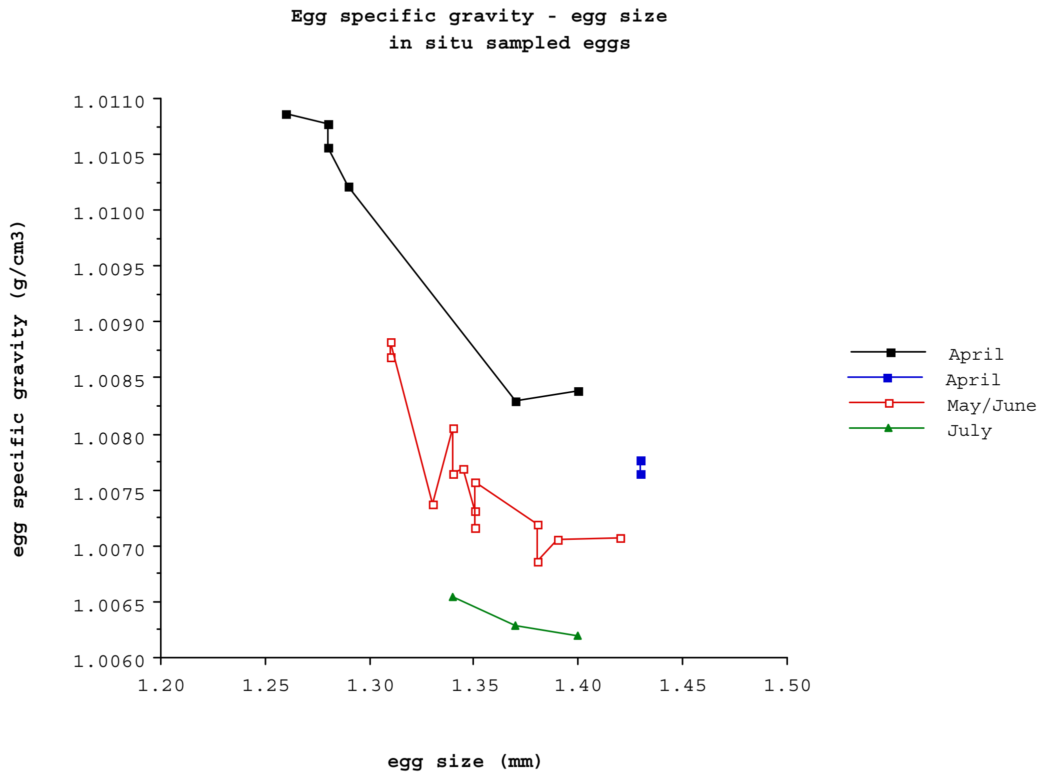

a)
EGG SPECIFIC GRAVITY
Gotland basin
April
number of eggs
g/cm3


a)
EGG SIZE
Gotland basin
April
number of eggs
mm

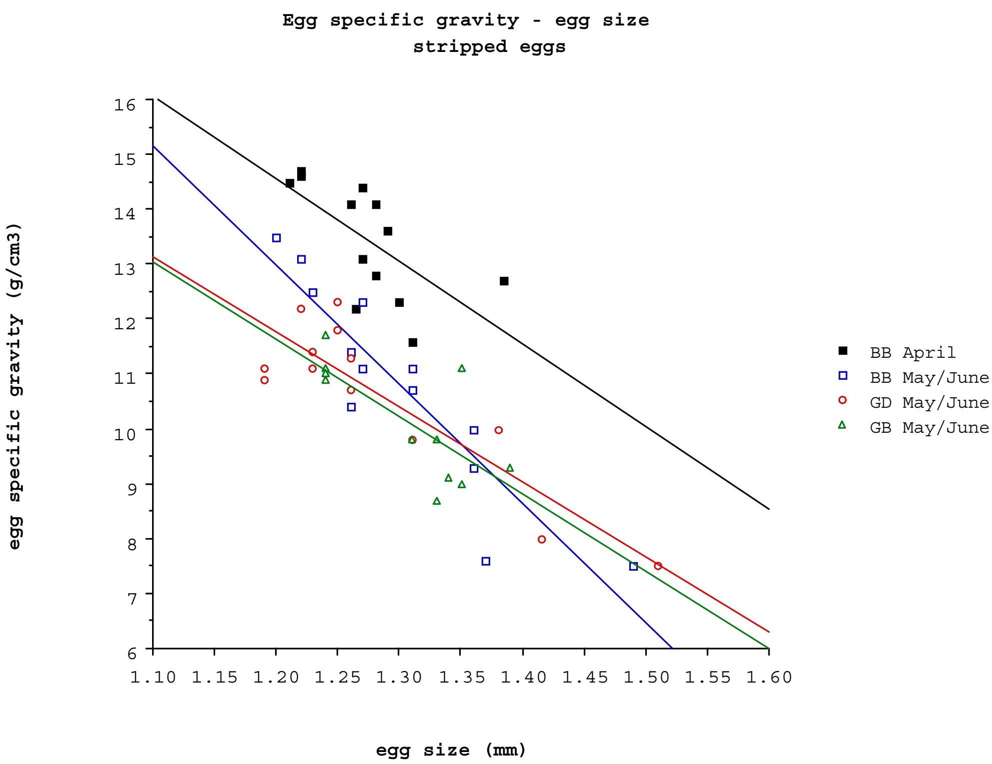




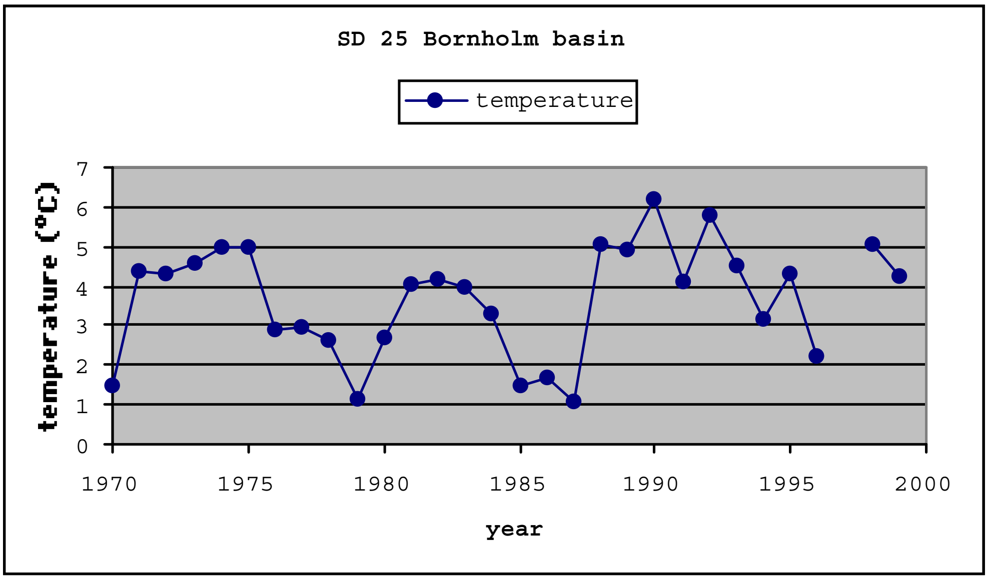
2.2.16. Egg specific gravity and egg size (preserved eggs) of in situ sampled sprat eggs from the Gotland basin in a) April b) late May/early June.



2.2.17. The relationship between egg size (preserved eggs) and egg specific gravity for in situ sampled eggs of sprat at different occasions during the spawning season.



2.2.18. The relationship between egg size (preserved eggs) and egg specific gravity for sprat eggs obtained by stripping. Sampling performed in the Bornholm basin (BB) in Aril and late May/early June, in the Gdansk deep (GD) in late May/early June and in the Gotland basin (GB) in late May/early June.



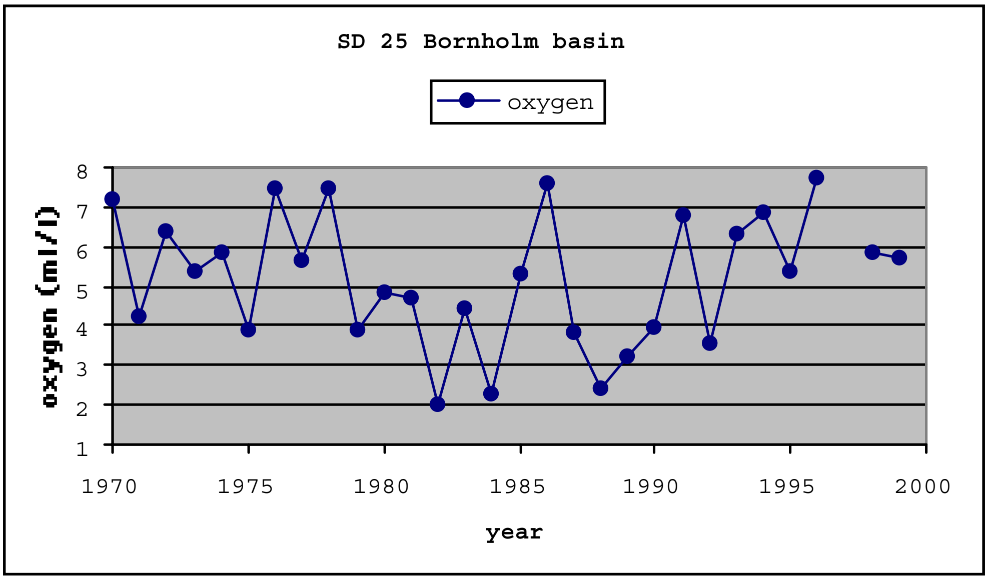


Figure 2.2.19. Temperature (°C) and oxygen (ml/l) conditions in the Bornholm Basin at the water depth corresponding to the in average egg specific gravity of Baltic sprat during peak spawning in May-June during the period 1970-2000.

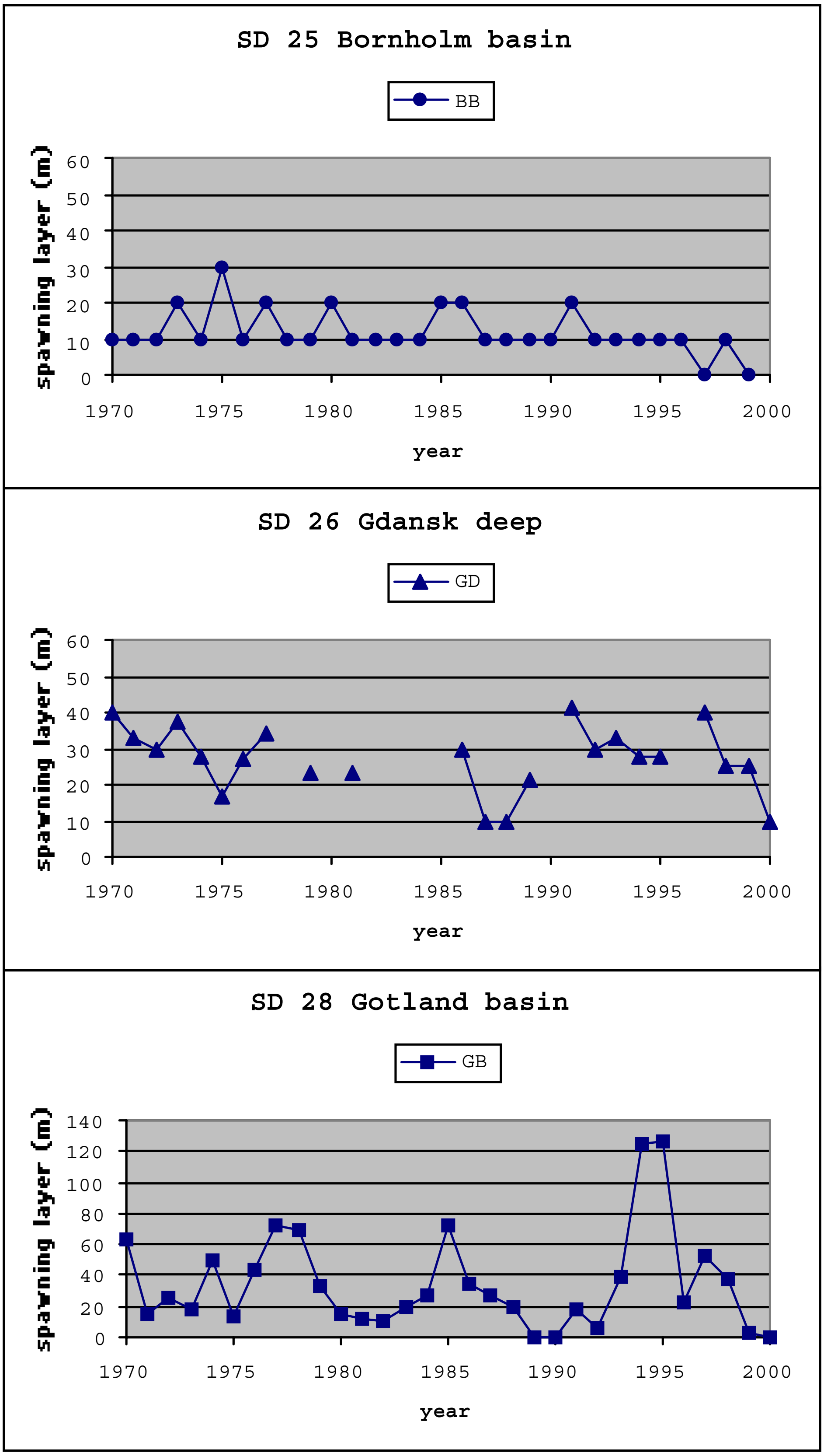
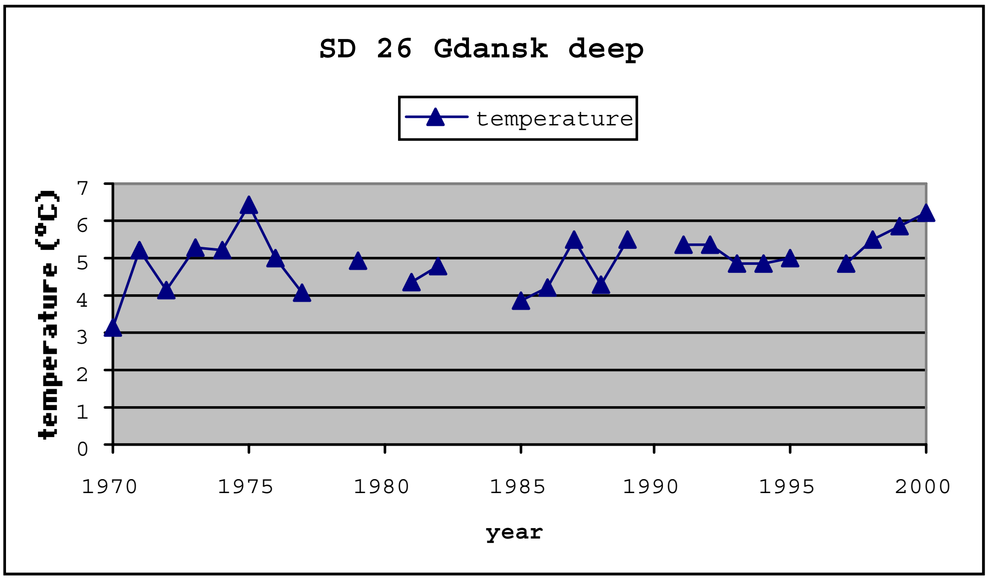


Figure 2.2.20. Magnitude of estimated spawning layer thickness during peak spawning for respective spawning area of Baltic sprat during the period 1970-2000.



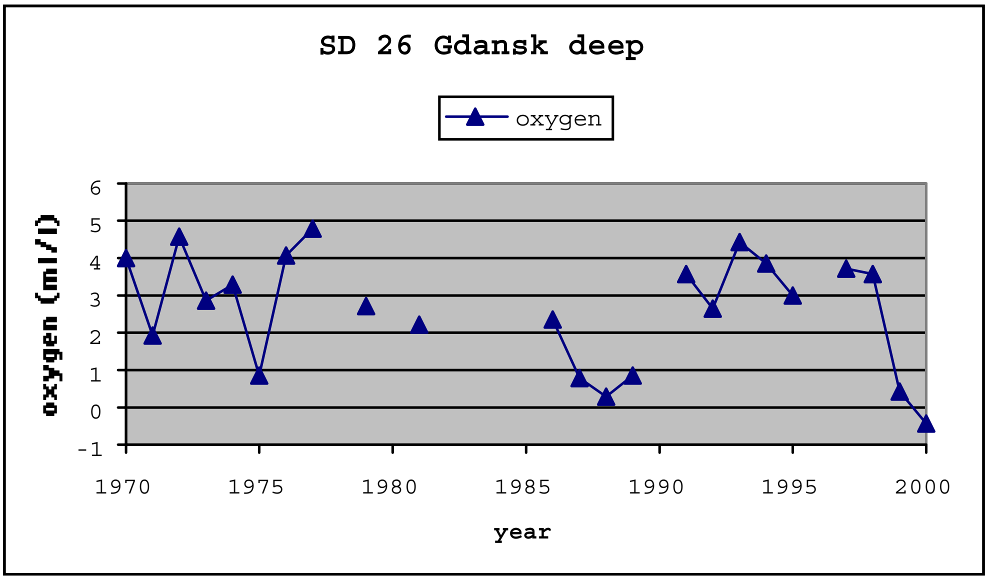
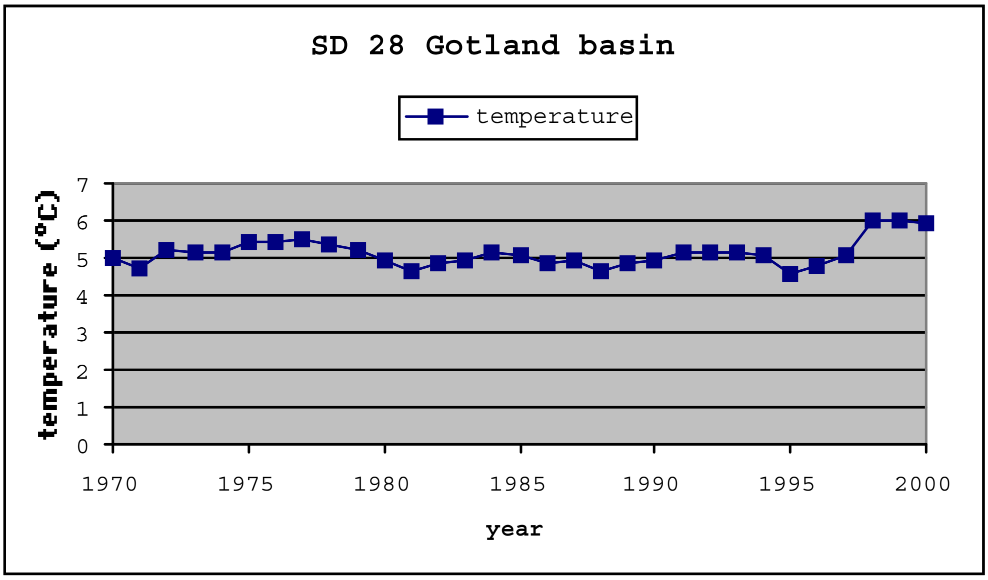


Figure 2.2.21. Temperature (°C) and oxygen (ml/l) conditions in the Gdansk Deep at the water depth corresponding to the in average egg specific gravity of Baltic sprat during peak spawning in May-June during the period 1970-2000.



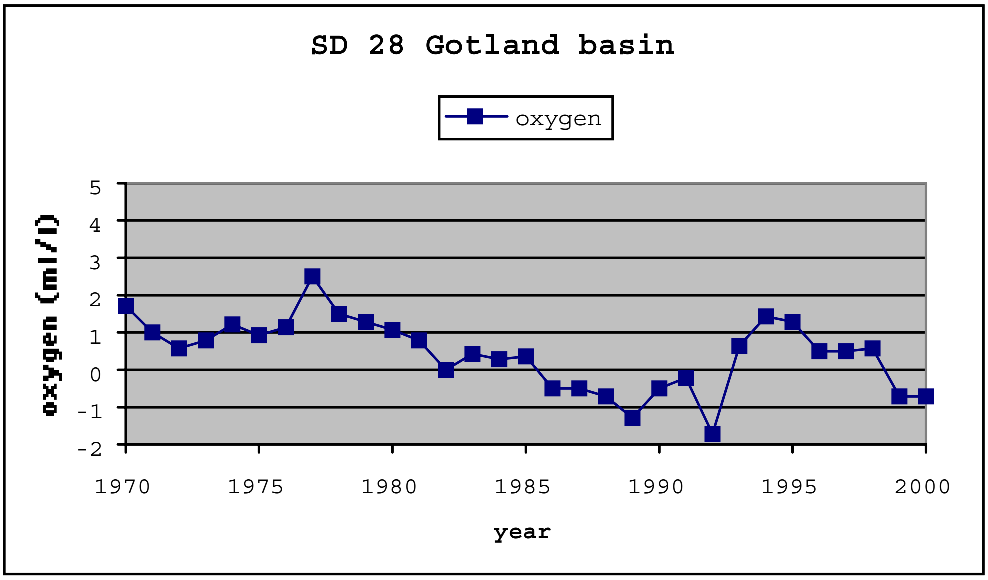


Figure 2.2.22. Temperature (°C) and oxygen (ml/l) conditions in the Gotland Basin at the water depth corresponding to the in average egg specific gravity of Baltic sprat during peak spawning in May-June during the period 1970-2000.

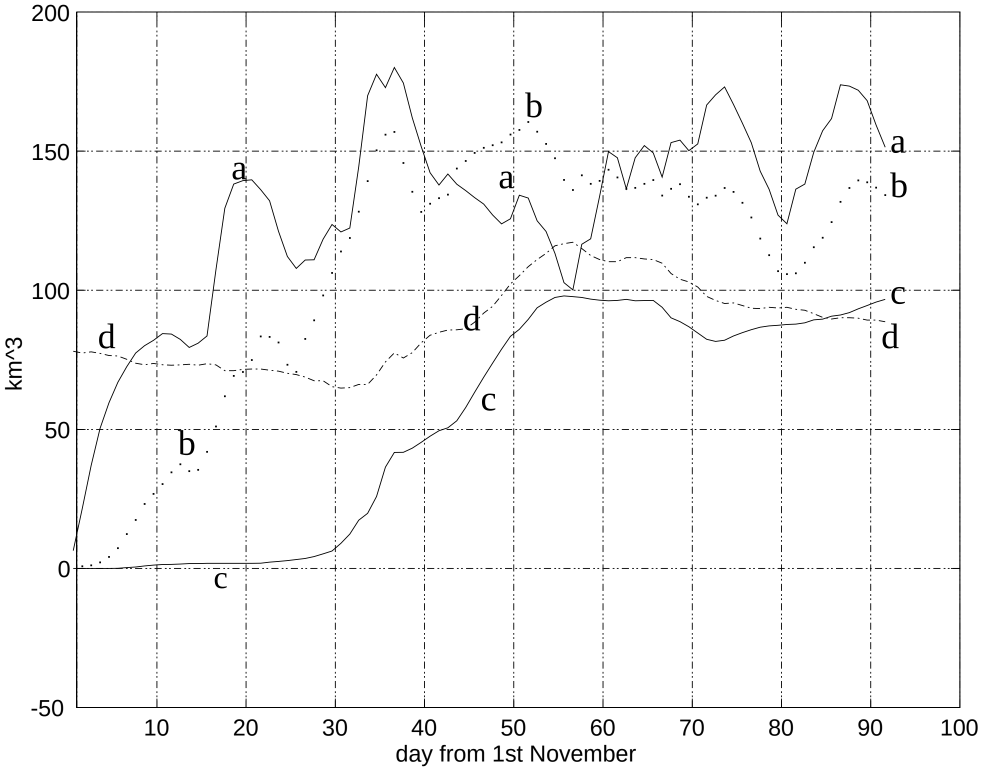


Fig. 2.3.1 Time series of cumulative transports of water masses suitable for successful spawning of Baltic cod eggs obtained from the reference model run utilizing realistic forcing conditions through a) the Danish Straits b) across 13 E c) through the Bornholm Gat and d) the reproduction volume in the Bornholm Basin.

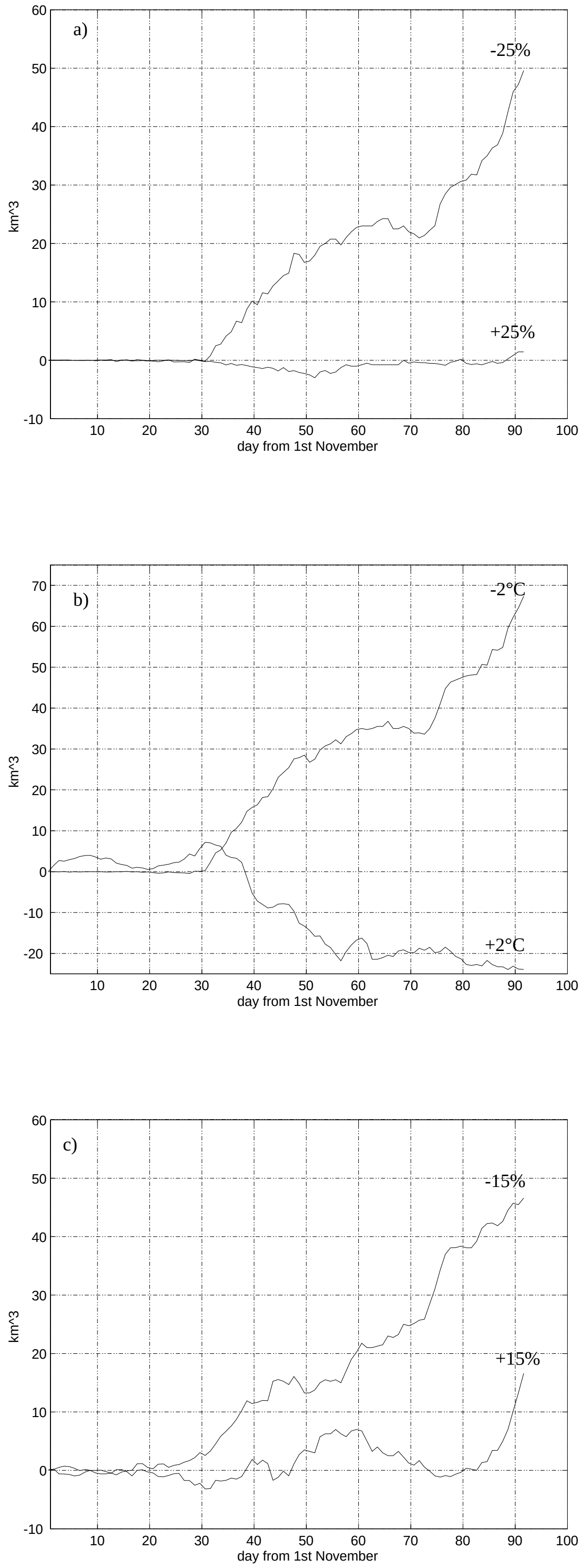


Fig. 2.3.2 Differences of reproduction volume with reference model run a) +-25% river runoff b) +-2 C of the near sea surface temperature and c) +-15% 2 decrease of wind stress strength.

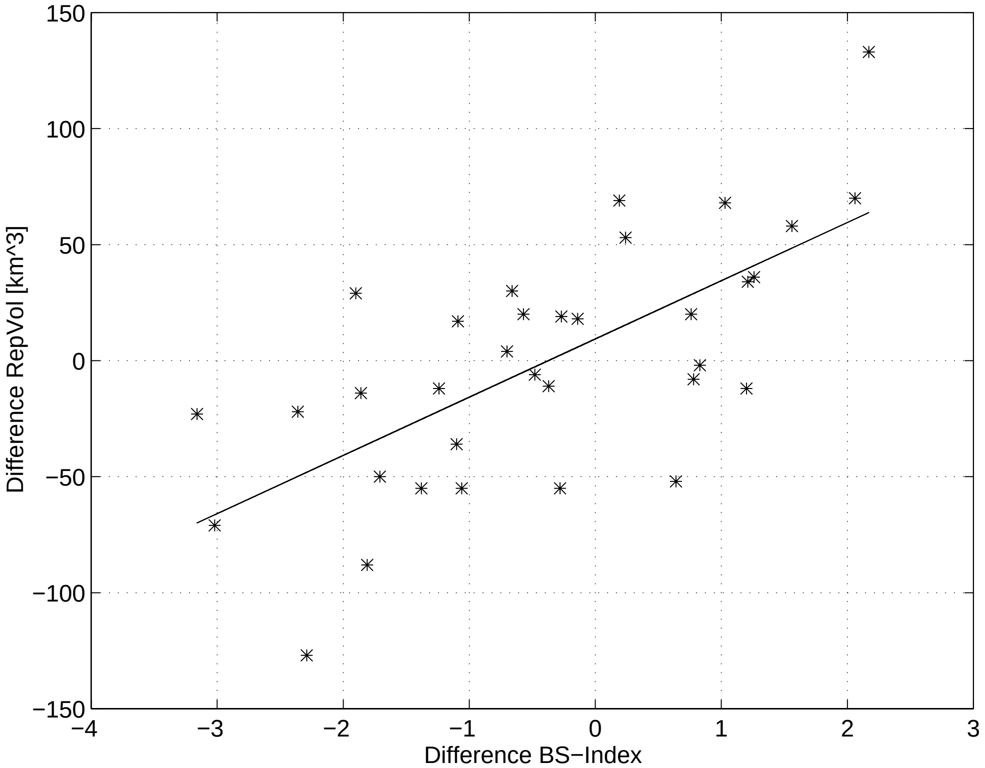


Fig. 2.3.3 Differences of BS-Index values 1. half minus 2. half of winter vs. differences of the reproduction volume 2. quarter minus 1. quarter of the year.

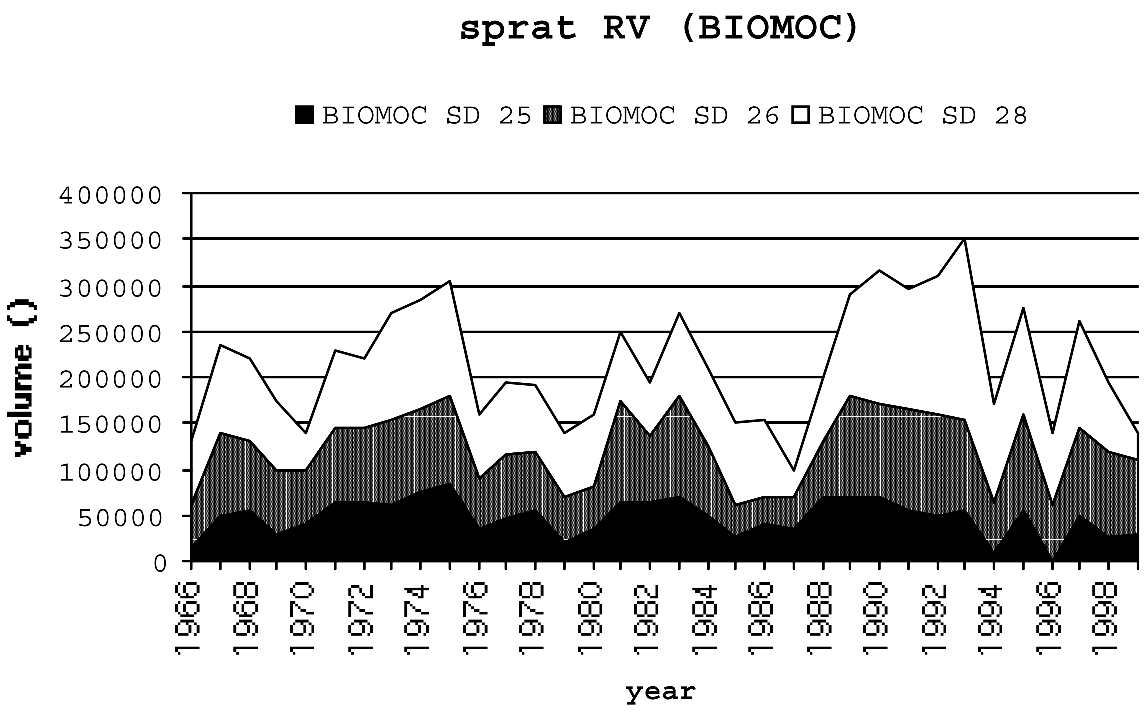


Fig. 2.3.4. Estimated reproductive volumes (km^3) for the main spawning areas, the Bornholm Basin (SD 25), the Gdansk Deep (SD 26) and the Gotland Basin (SD 28), of Baltic sprat during the period 1966-1999 based on vertical egg distributions from *in situ* sampling (BIOMOC).

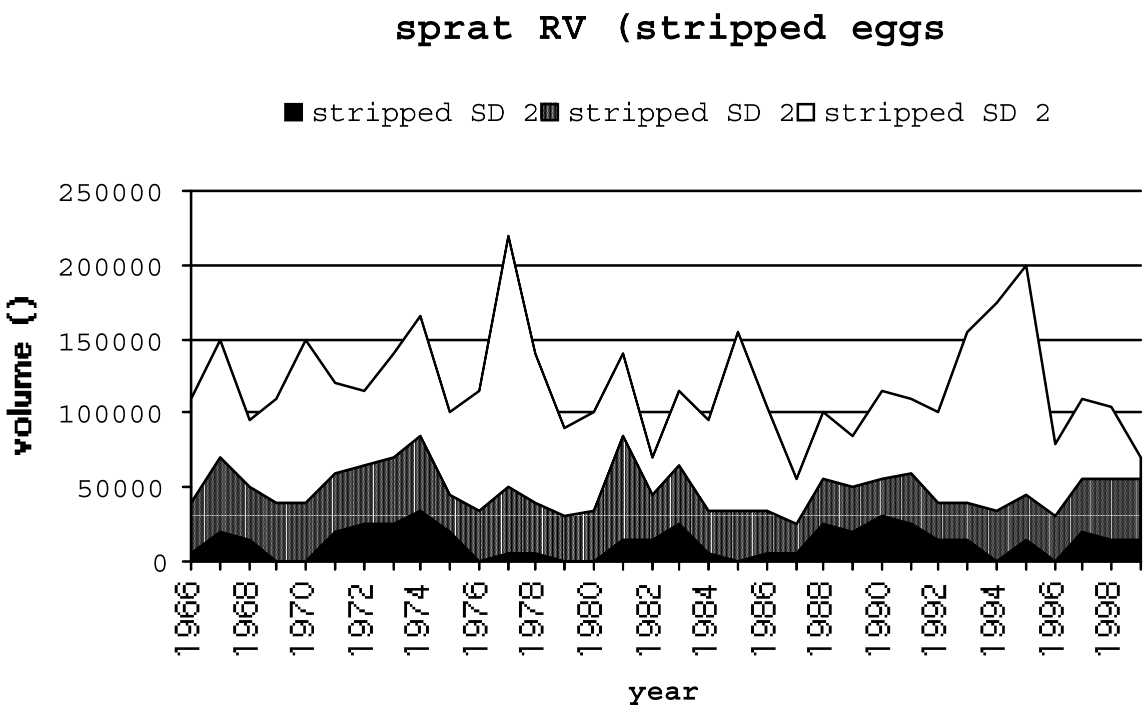
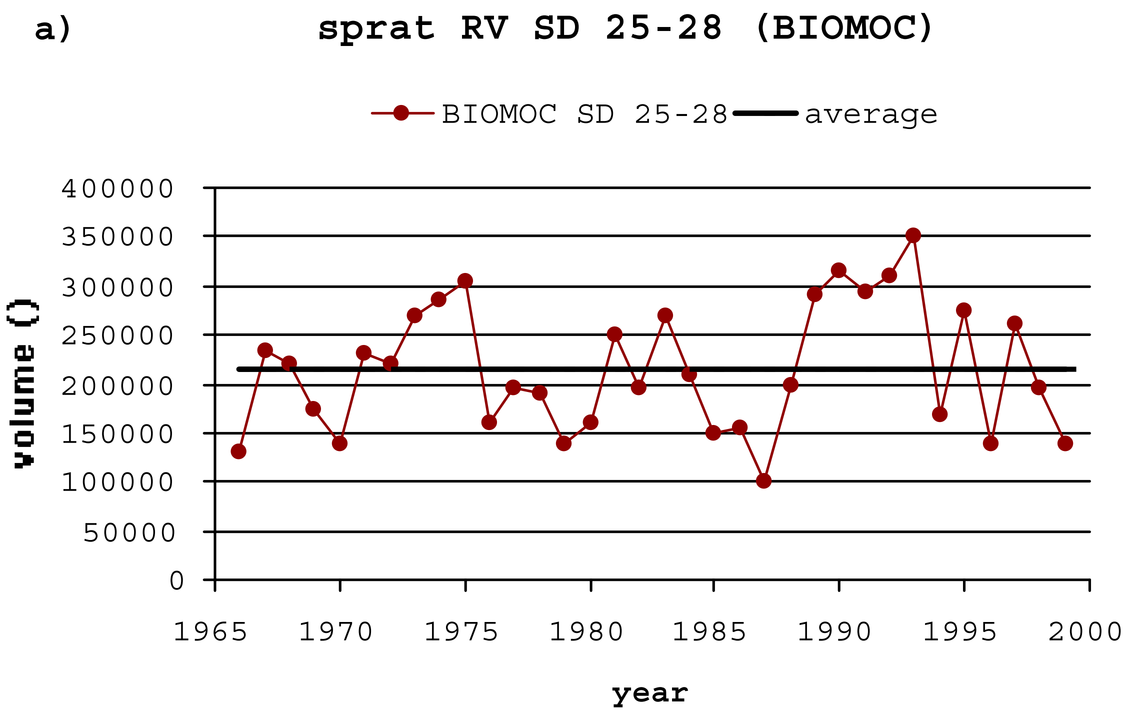


Fig. 2.3.5. Estimated reproductive volumes for the main spawning areas, the Bornholm Basin (SD 25), the Gdansk Deep (SD 26) and the Gotland Basin (SD 28), of Baltic sprat during the period 1966-1999 based on vertical egg distribution from egg specific gravity measurements of stripped eggs.

a)



b)

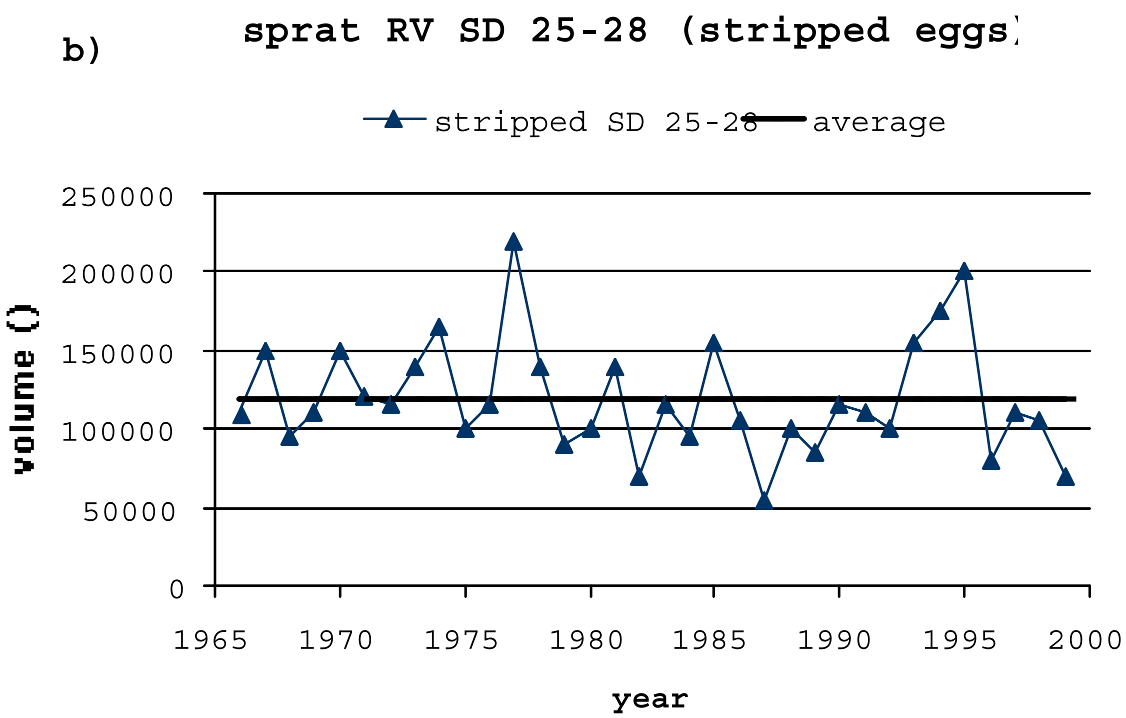


Fig. 2.3.6. Estimated total reproductive volumes (km^3) of Baltic sprat during the period 1966-1999 based on a) vertical egg distributions from *in situ* sampling (BIOMOC) and b) vertical egg distribution from egg specific gravity measurements of stripped eggs. Solid lines refer to the in average RV during the period.

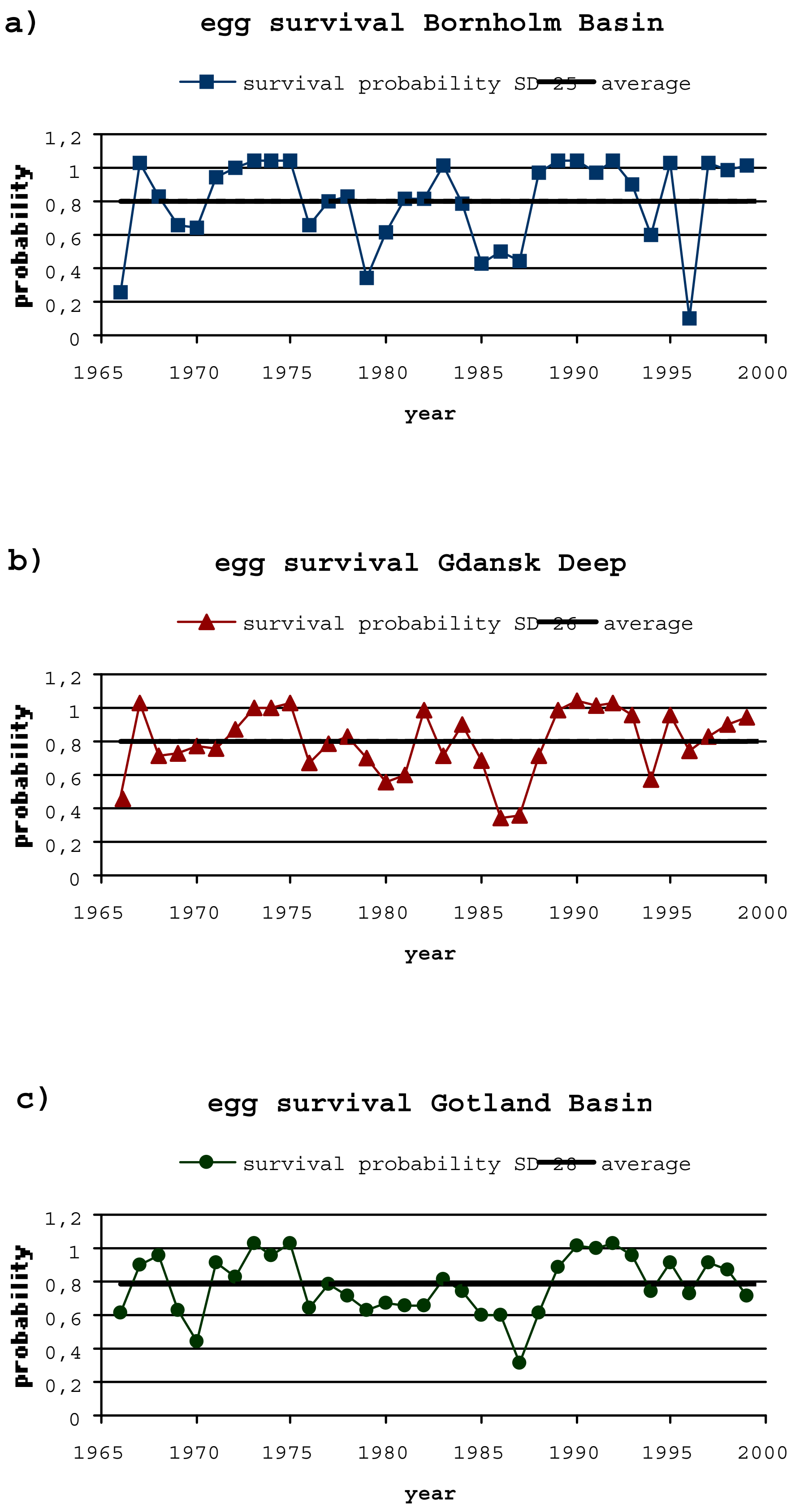


Fig. 2.3.7. Estimated temperature related egg survival probabilities in respective spawning area of Baltic sprat during the period 1966-1999; a) the Bornholm Basin (SD 25), b) the Gdansk Deep (SD 26) and c) the Gotland Basin (SD 28). Solid lines refer to the in average egg survival probability during the period.

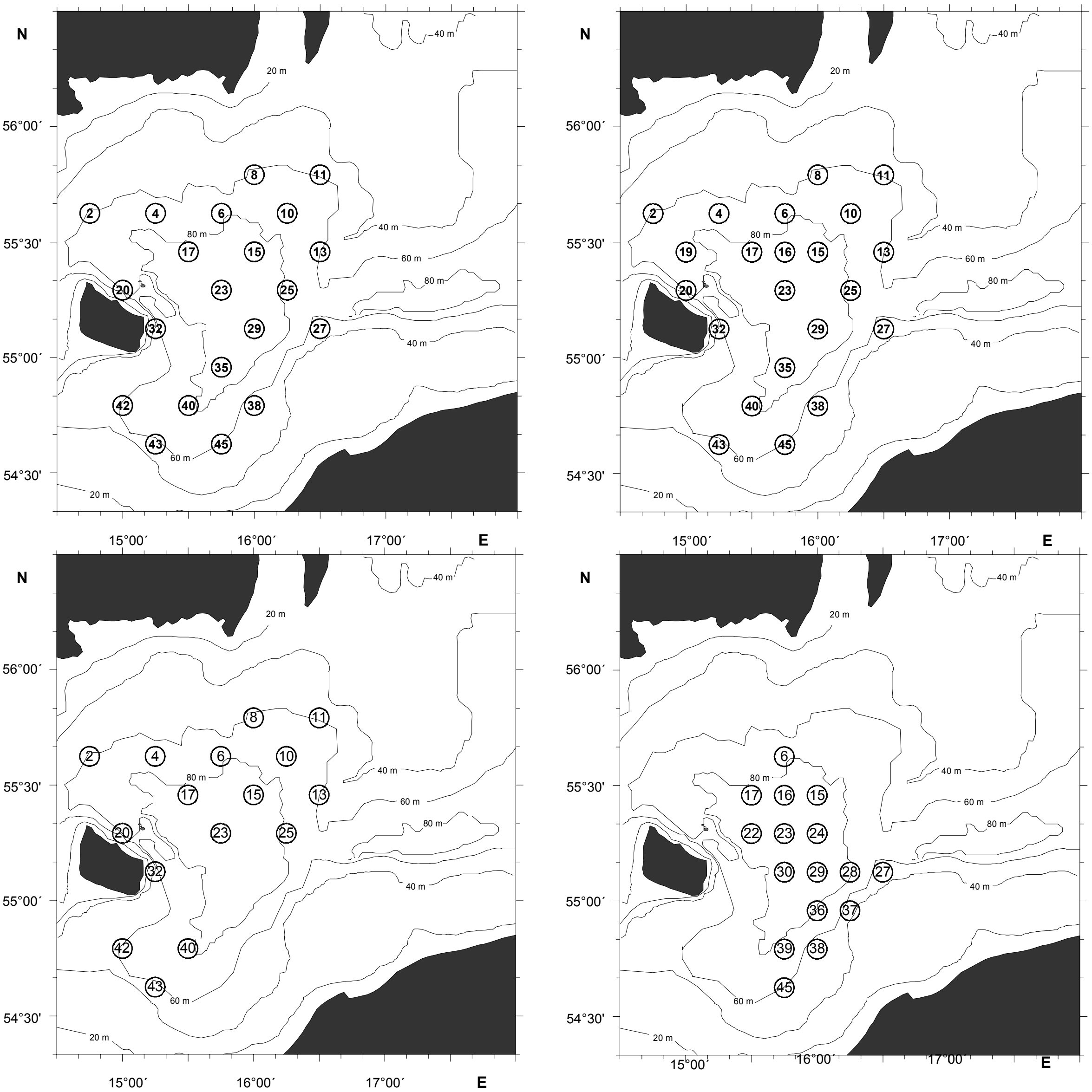


Fig. 3.1.1. Stations of the meso-scale sampling grid in the Bornholm Basin in 1999 analyzed for horizontal distribution of zooplankton species/stages in April and June (upper left panel), May (upper right panel), as well as August (lower left panel for 50µm-samples; lower right panel for 150µm-samples).

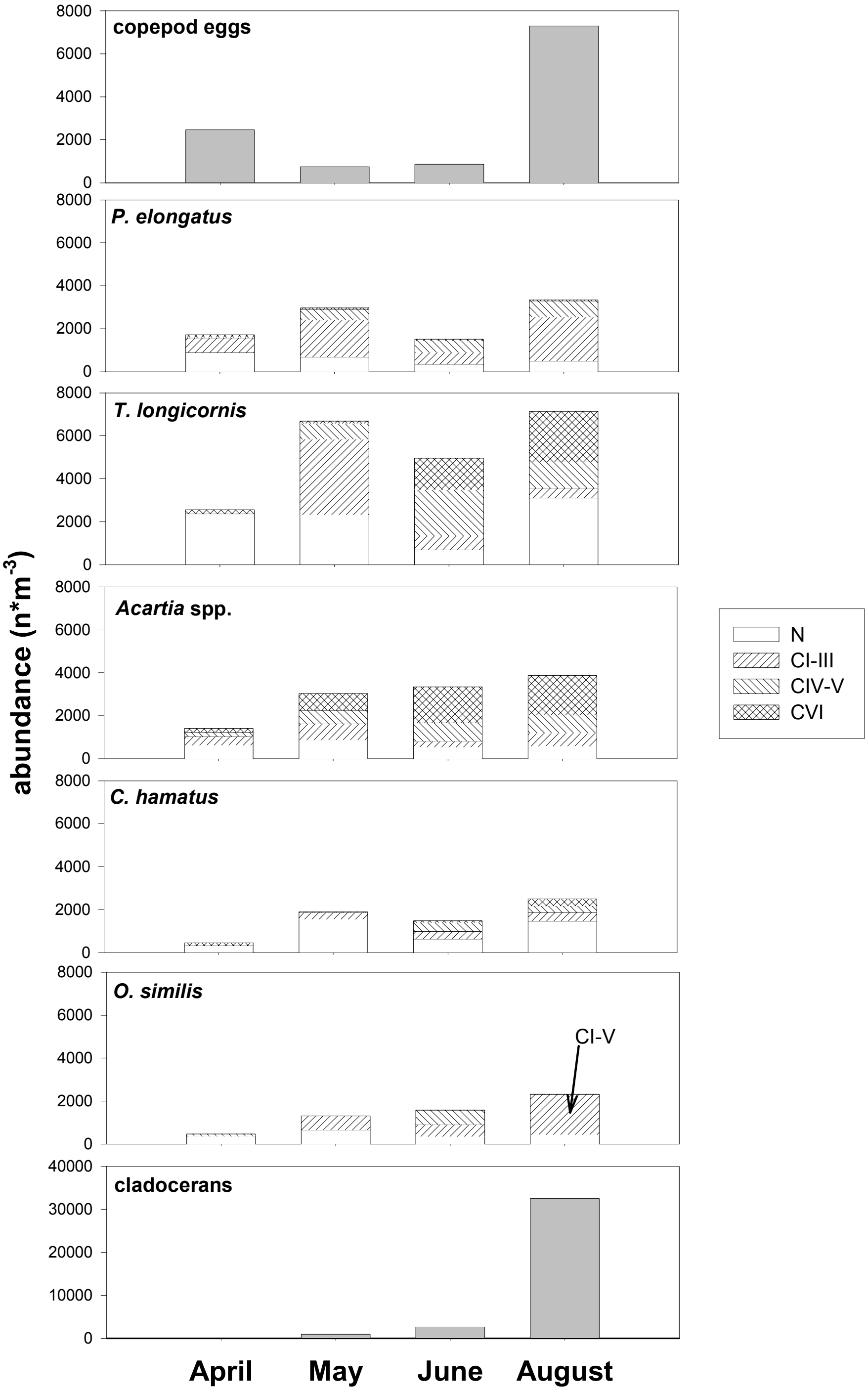


Fig. 3.1.2. Average seasonal develoment in abundance of copepod eggs and mesozooplankton species/stages in the Bornholm Basin in 1999.

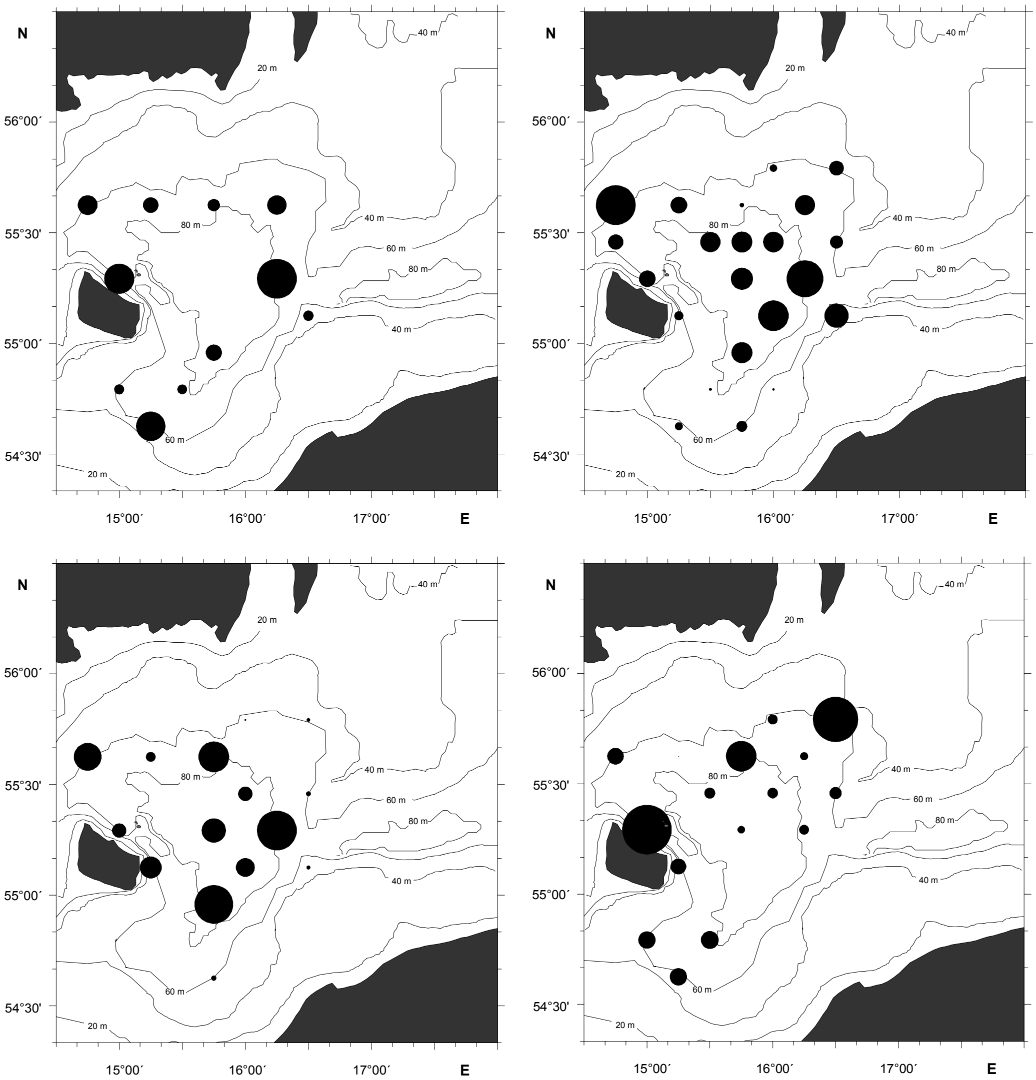


Fig. 3.1.3. Horizontal distribution of copepod eggs in the Bornholm Basin in April (upper left panel), May (upper right panel), June (lower left panel) and August (lower right pane) in 1999. Note different scaling – smallest circle and largest circle represent lowest and highest abundance per month respectively.

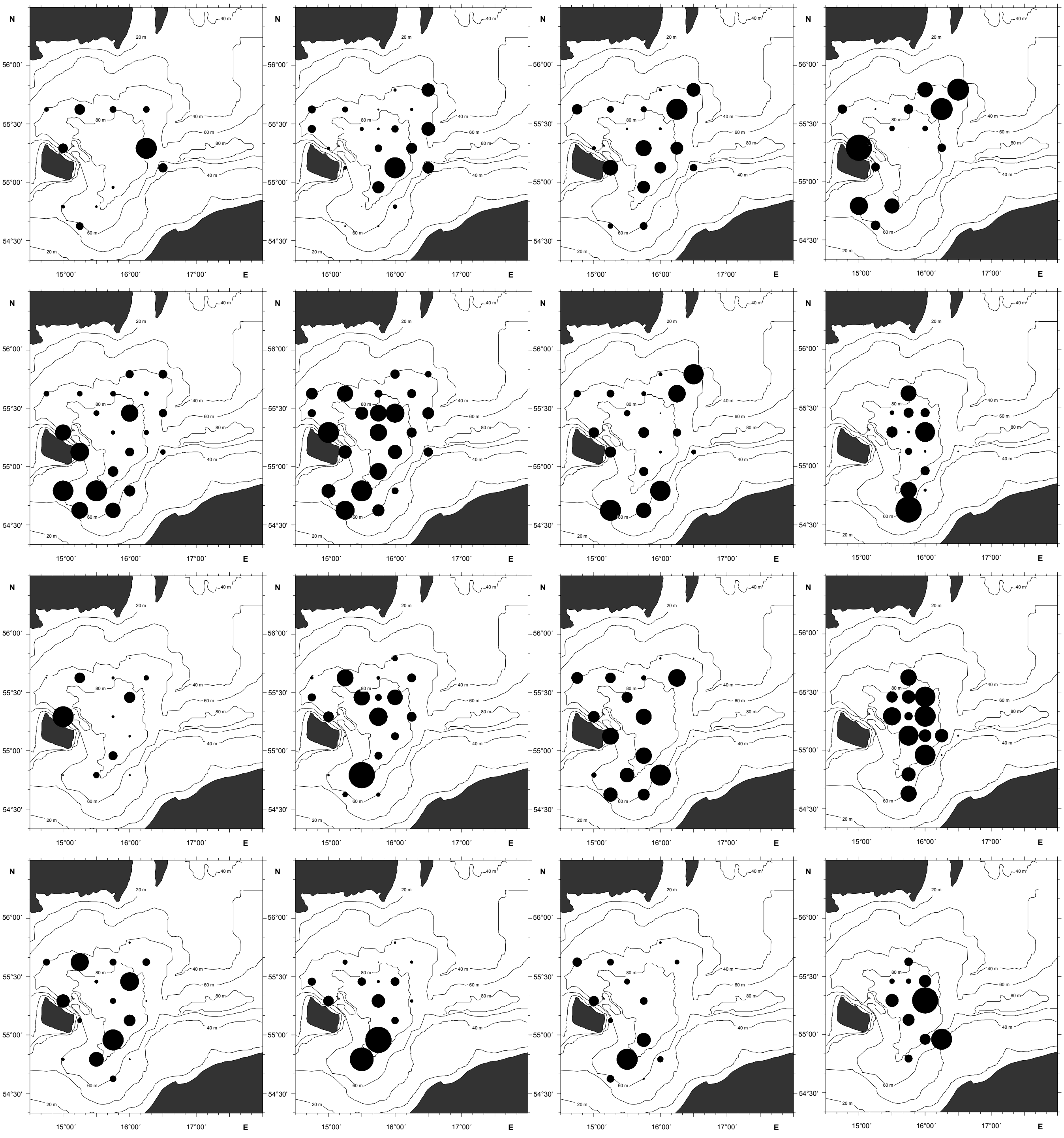


Fig. 3.1.4. Horizontal distribution of *P. elongatus* life-stages (N:1st row; CI-III:2nd row; CIV-V:3rd row; CVI: 4th row) in the Bornholm Basin in April (1st column), May (2nd column), June (3rd column)and August (4th column) in 1999. Note different scaling – smallest circle and largest circle represent lowest and highest abundance per month respectively.

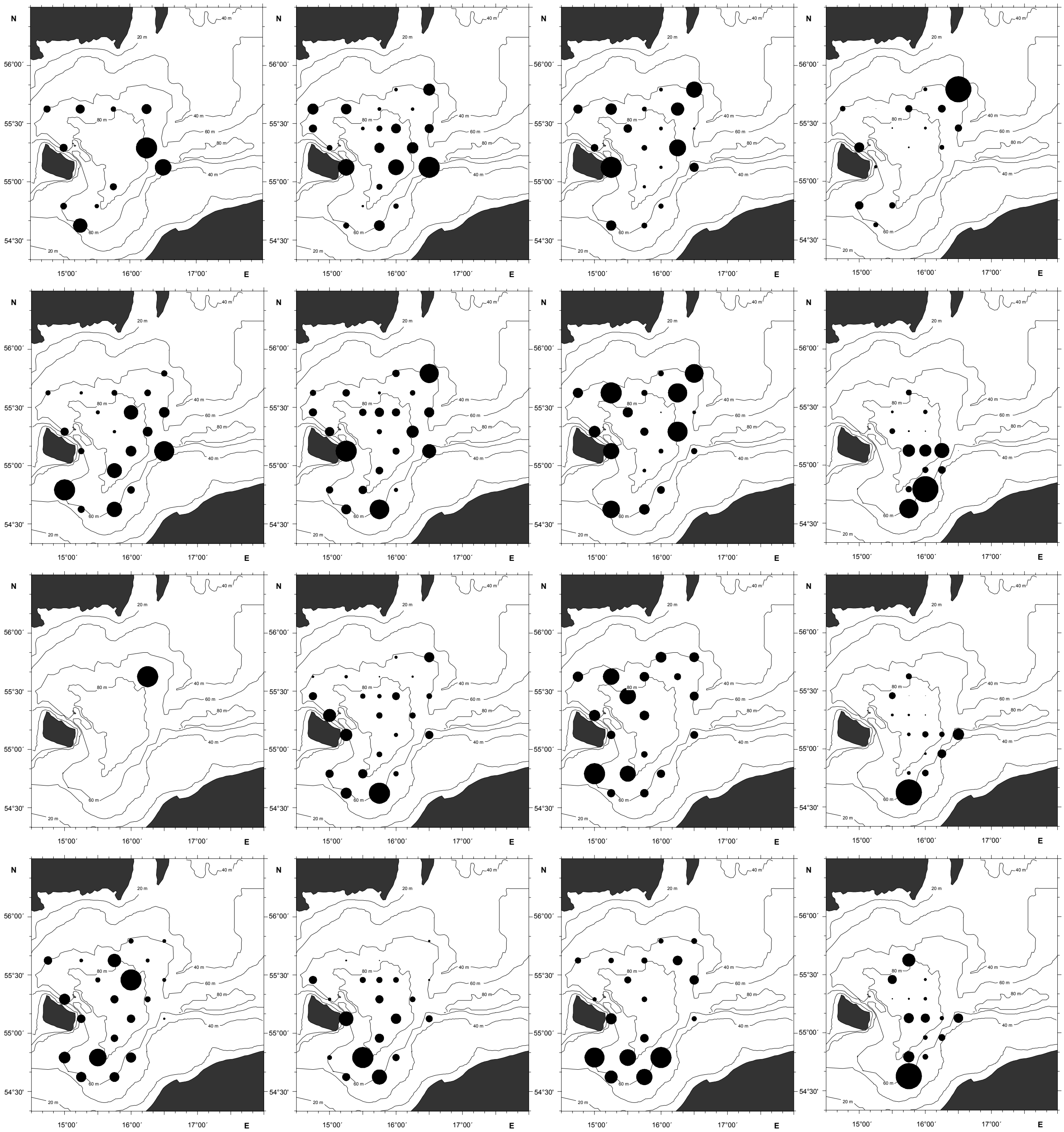


Fig. 3.1.5. Horizontal distribution of *T. longicornis* life-stages (N:1st row; CI-III:2nd row; CIV-V:3rd row; CVI: 4th row) in the Bornholm Basin in April (1st column), May (2nd column), June (3rd column) and August (4th column) in 1999. Note different scaling – smallest circle and largest circle represent lowest and highest abundance per month respectively.

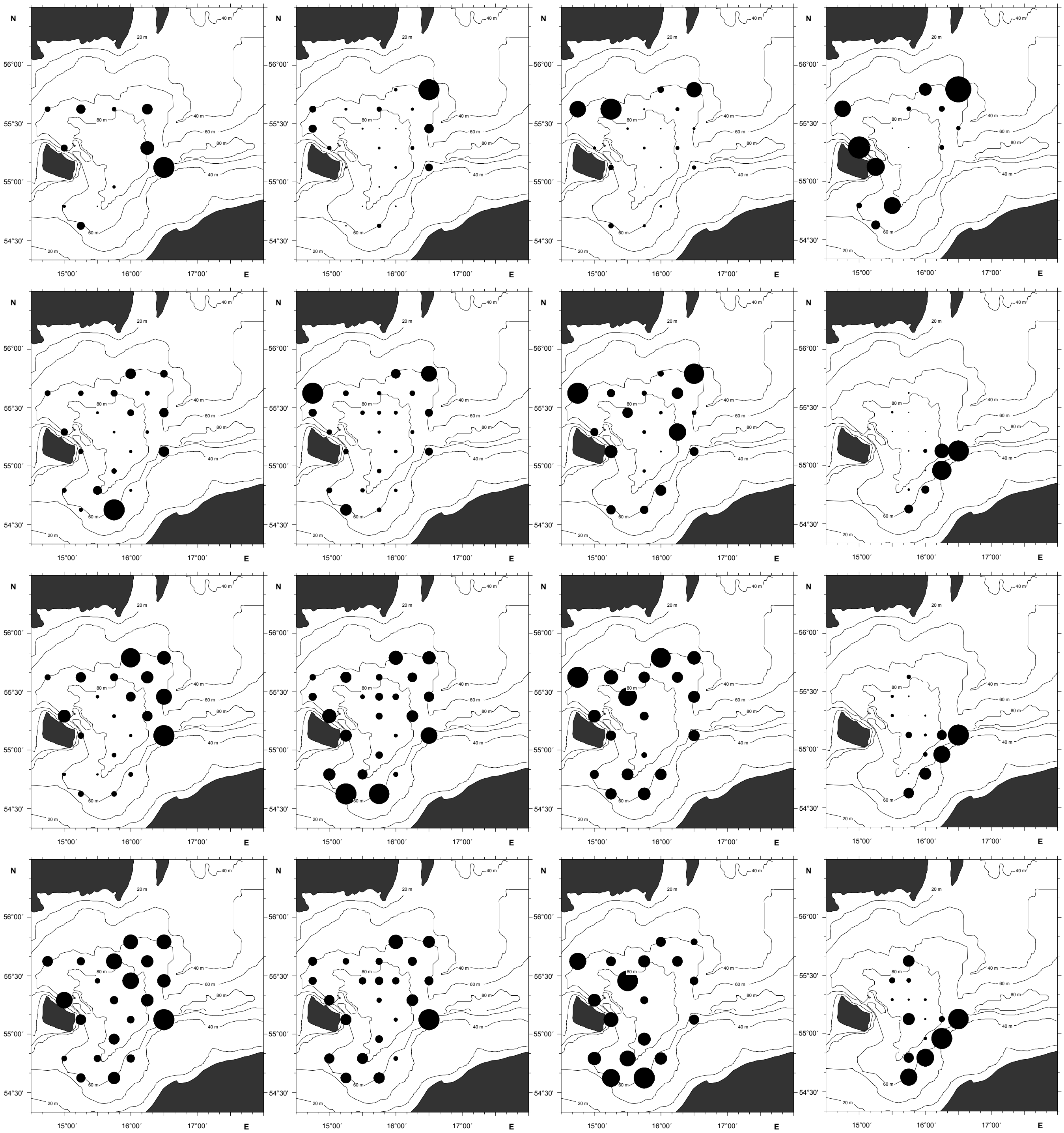


Fig. 3.1.6. Horizontal distribution of *Acartia* spp. life-stages (N:1st row; CI-III:2nd row; CIV-V:3rd row; CVI: 4th row) in the Bornholm Basin in April (1st column), May (2nd column), June (3rd column) and August (4th column) in 1999. Note different scaling – smallest circle and largest circle represent lowest and highest abundance per month respectively.

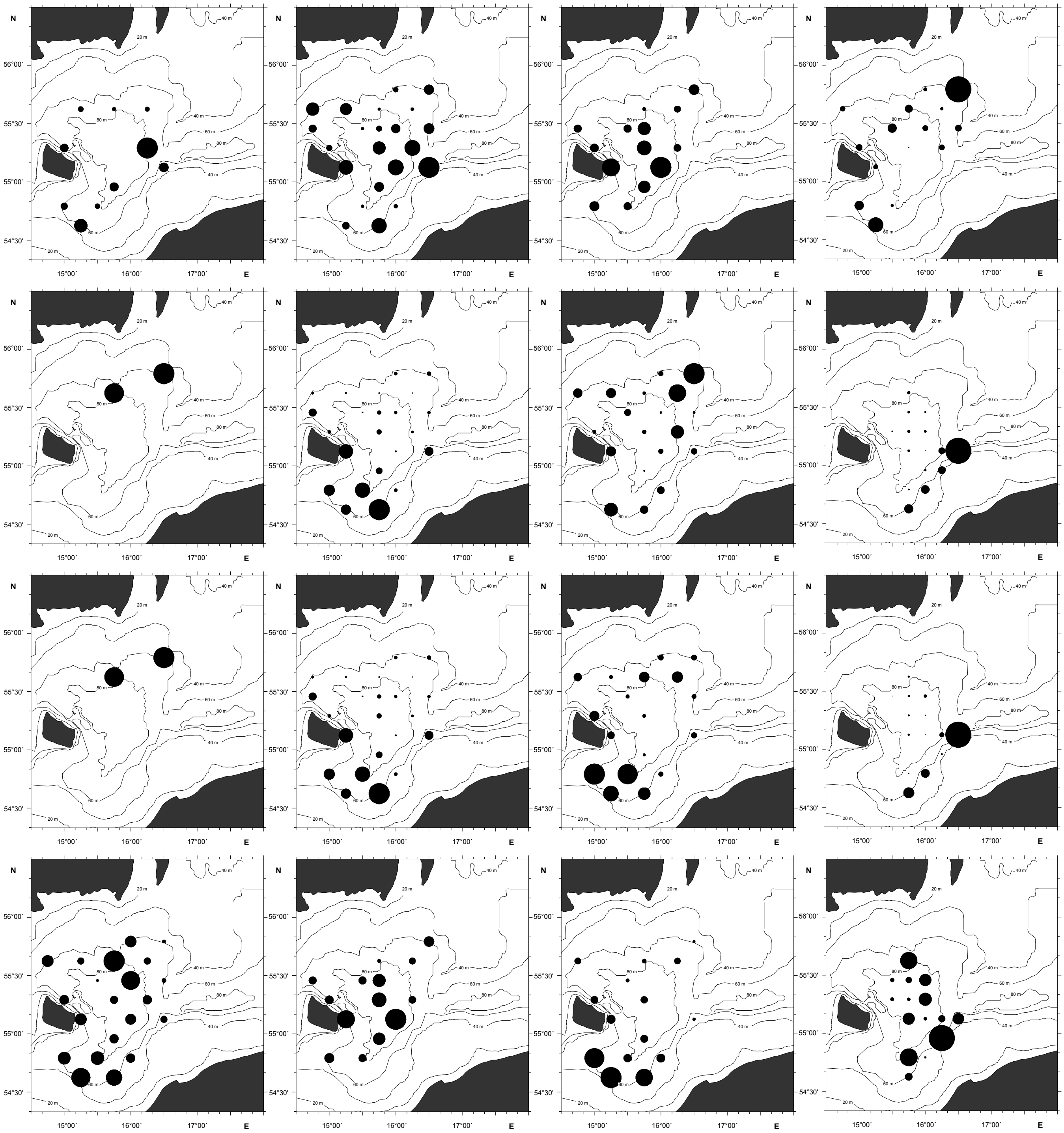


Fig. 3.1.7. Horizontal distribution of *C. hamatus* life-stages (N:1st row; CI-III:2nd row; CIV-V:3rd row; CVI: 4th row) in the Bornholm Basin in April (1st column), May (2nd column), June (3rd column) and August (4th column) in 1999. Note different scaling – smallest circle and largest circle represent lowest and highest abundance per month respectively.

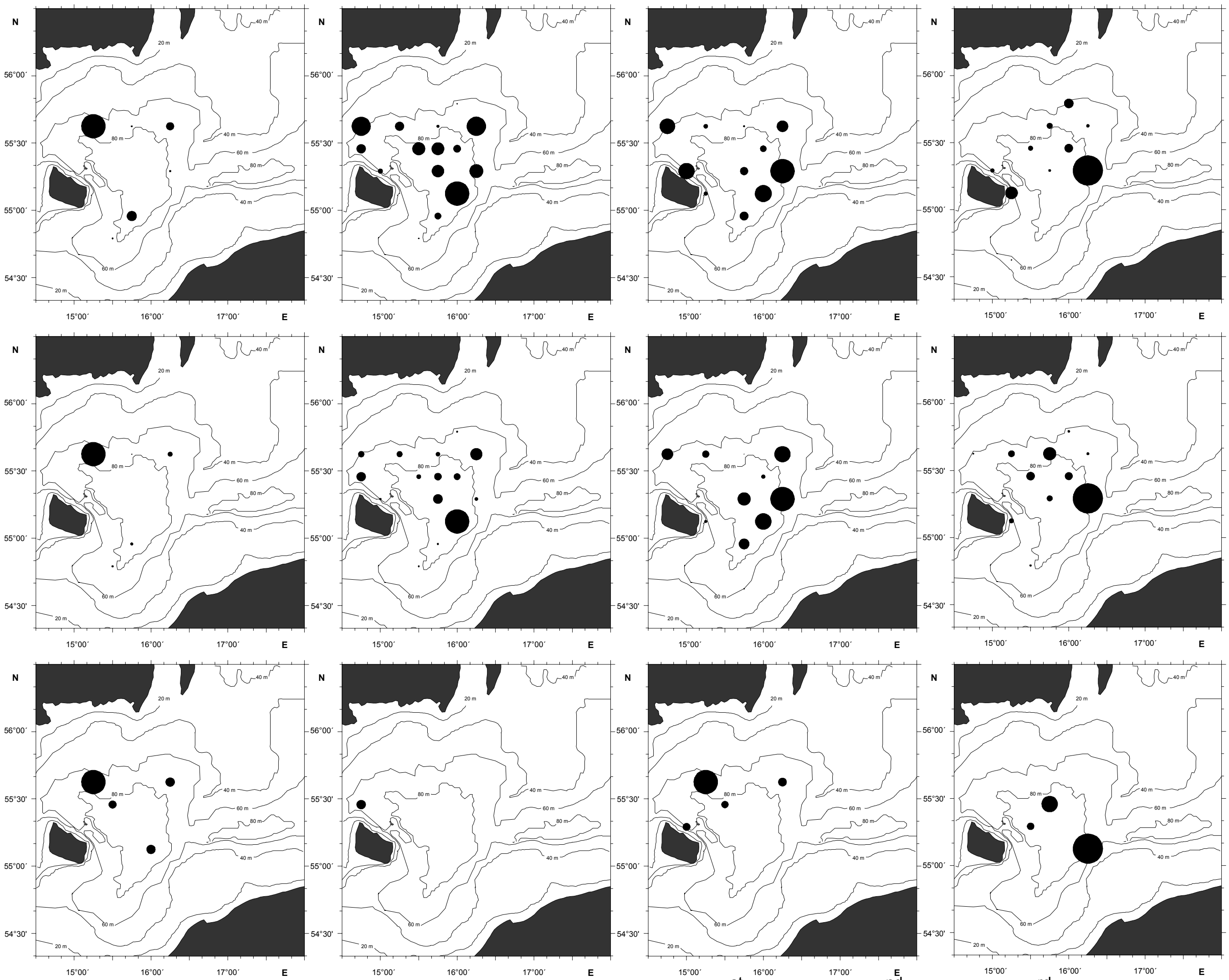


Fig. 3.1.8. Horizontal distribution of *O. similis* life-stages (N:1st row; CI-V:2nd row; CVI:3rd row) in the Bornholm Basin in April (1st column), May (2nd column), June (3rd column) and August (4th column) in 1999. Note different scaling – smallest circle and largest circle represent lowest and highest abundance per month respectively.

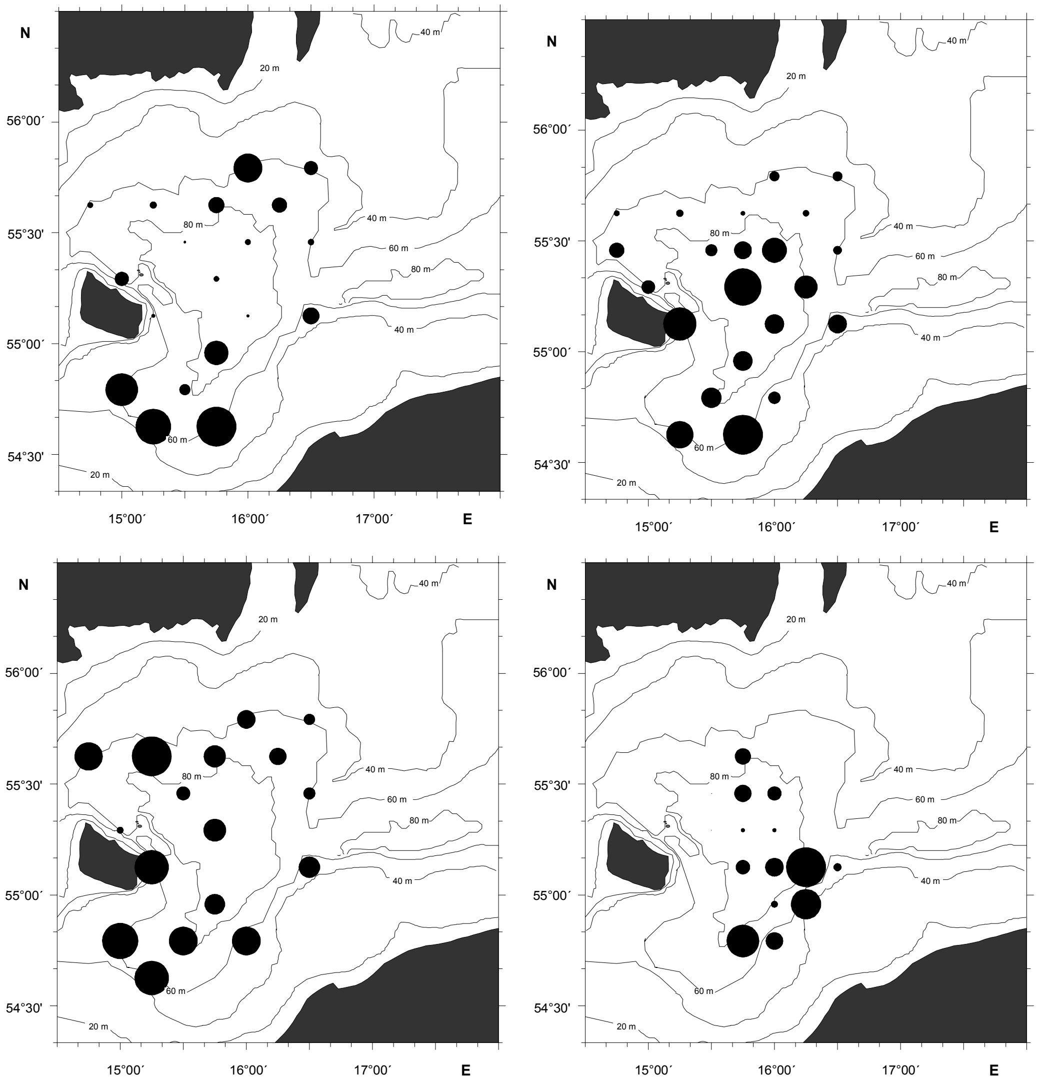


Fig. 3.1.9. Horizontal distribution of cladocerans in the Bornholm Basin in April (upper left panel), May (upper right panel), June (lower left panel) and August (lower right pane) in 1999. Note different scaling – smallest circle and largest circle represent lowest and highest abundance per month respectively.

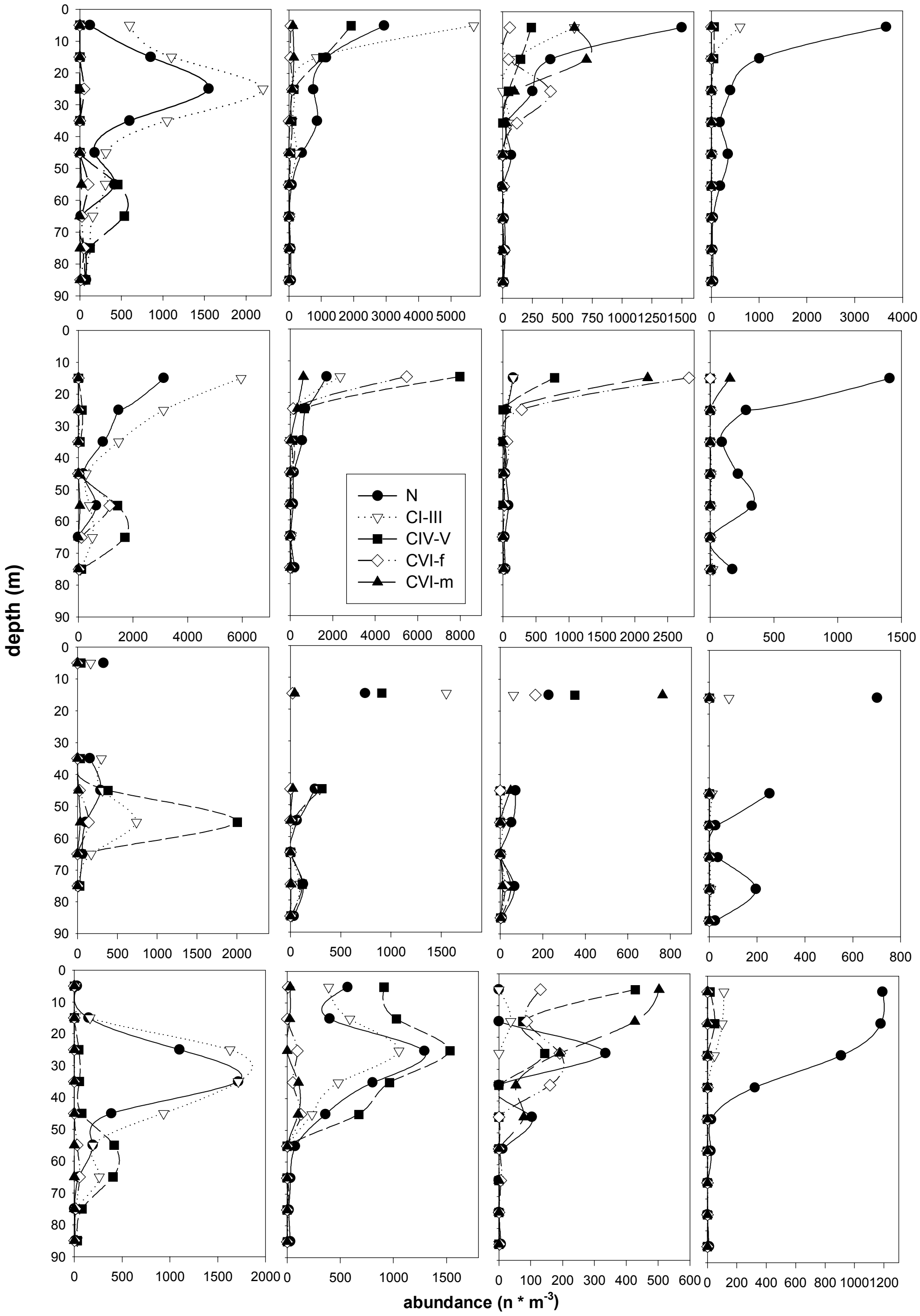


Fig. 3.1.10a. Vertical distribution of zooplankton species/stages in the Bornholm Basin in May 1999: *P. elongatus* (1st column), *T. longicornis* (2nd column), *Acartia* spp. (3rd column) and *C. hamatus* (4th column); sampling times: 01:30 (1st row), 04:00 (2nd row), 14:00 (3rd row) and 21:00 (4th row).

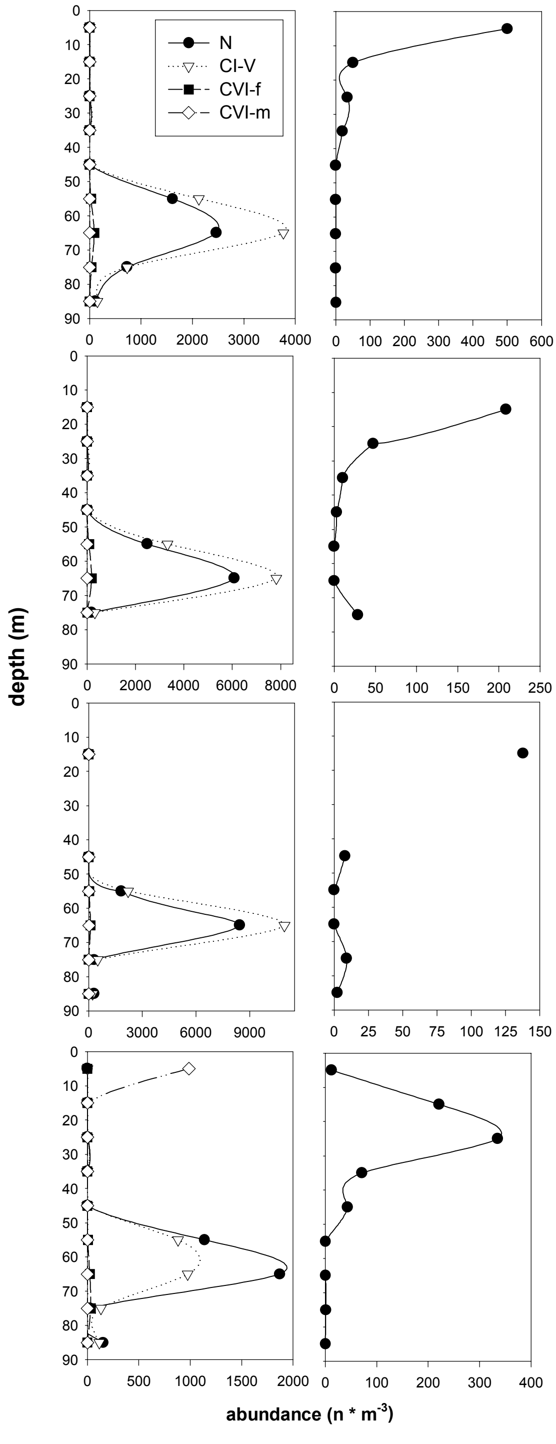


Fig. 3.1.10b. Vertical distribution of zooplankton species/stages in the Bornholm Basin in May 1999: *O. similis* (1st column) and cladocerans (2nd column) ; sampling times: 01:30 (1st row), 04:00 (2nd row), 14:00 (3rd row) and 21:00 (4th row).

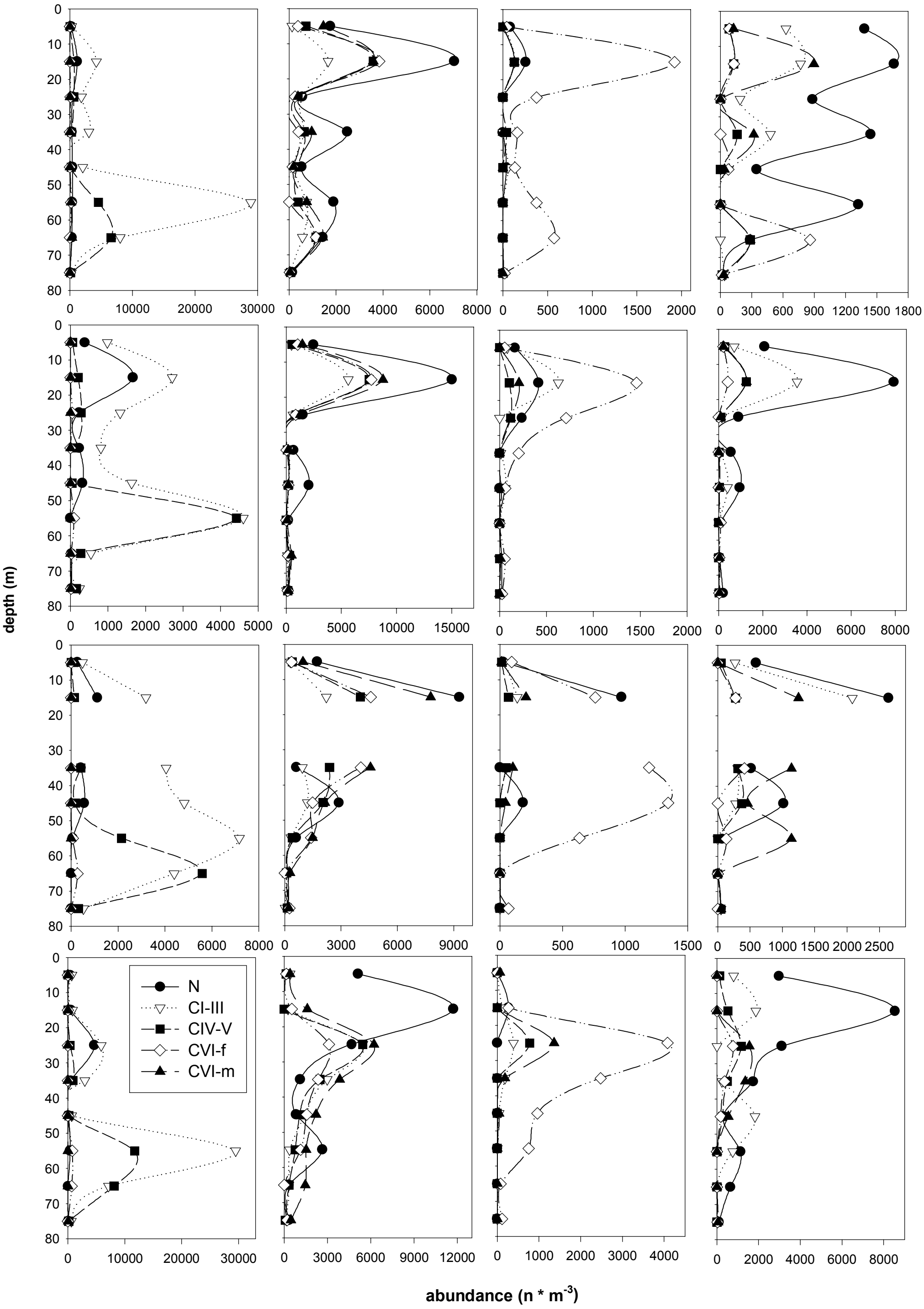


Fig. 3.1.11a. Vertical distribution of zooplankton species/stages in the Bornholm Basin in August 1999: *P. elongatus* (1st column), *T. longicornis* (2nd column), *Acartia* spp. (3rd column) and *C. hamatus* (4th column); sampling times: 01:30 (1st row), 04:30 (2nd row), 13:30 (3rd row) and 19:30 (4th row).

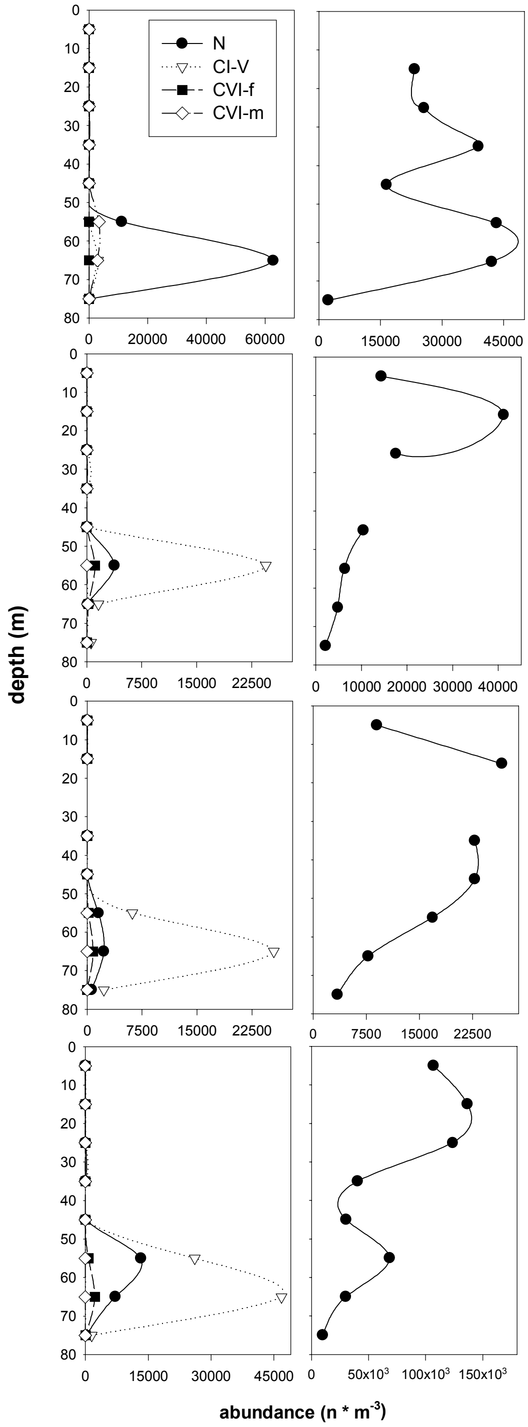


Fig. 3.1.11b. Vertical distribution of zooplankton species/stages in the Bornholm Basin in August 1999: *O. similis* (1st column) and cladocerans (2nd column) ; sampling times: 01:30 (1st row), 04:30 (2nd row), 13:30 (3rd row) and 19:30 (4th row).

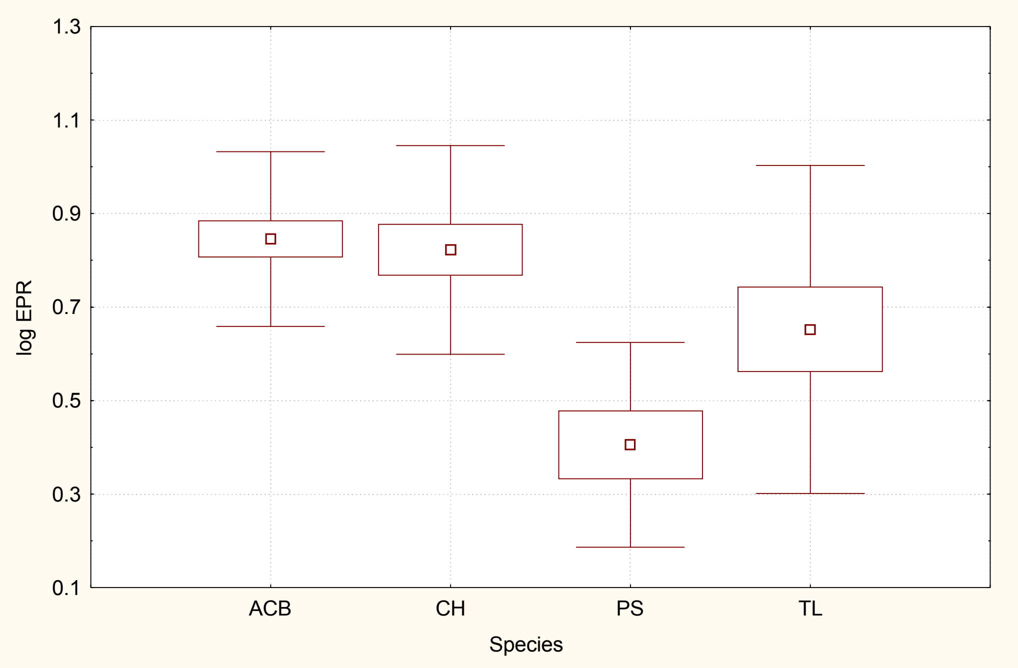


Fig. 3.1.12. Box-Whisker-Plot for copepod egg production (log EPR) vs. species (ACB - *Acartia bifilosa*, CH - *Centropages hamatus*, PS - *Pseudocalanus elongatus,* and TL – *Temora longicornis*); small squares – means, boxes – stand errors, and bars – standard deviations.

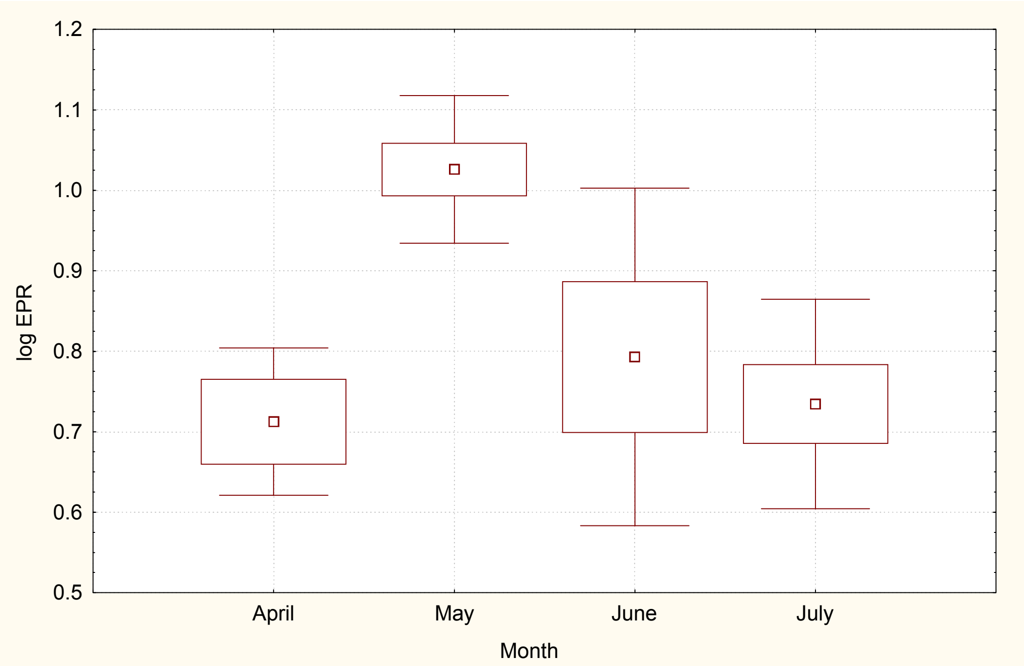


Fig. 3.1.13. Box-Whisker-Plot for copepod egg production (log EPR) vs. month for *Acartia bifilosa*; small squares – means, boxes – stand errors, and bars – standard deviations.

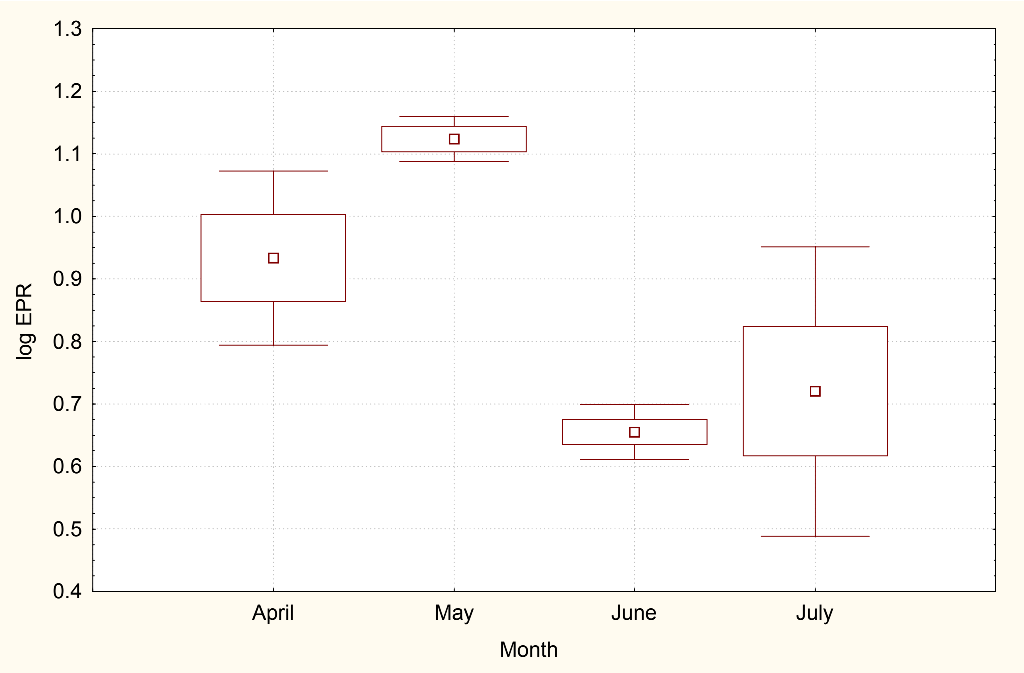


Fig. 3.1.14. Box-Whisker-Plot for copepod egg production (log EPR) vs. month for *Centropages hamatus*; small squares – means, boxes – stand errors, and bars – standard deviations.

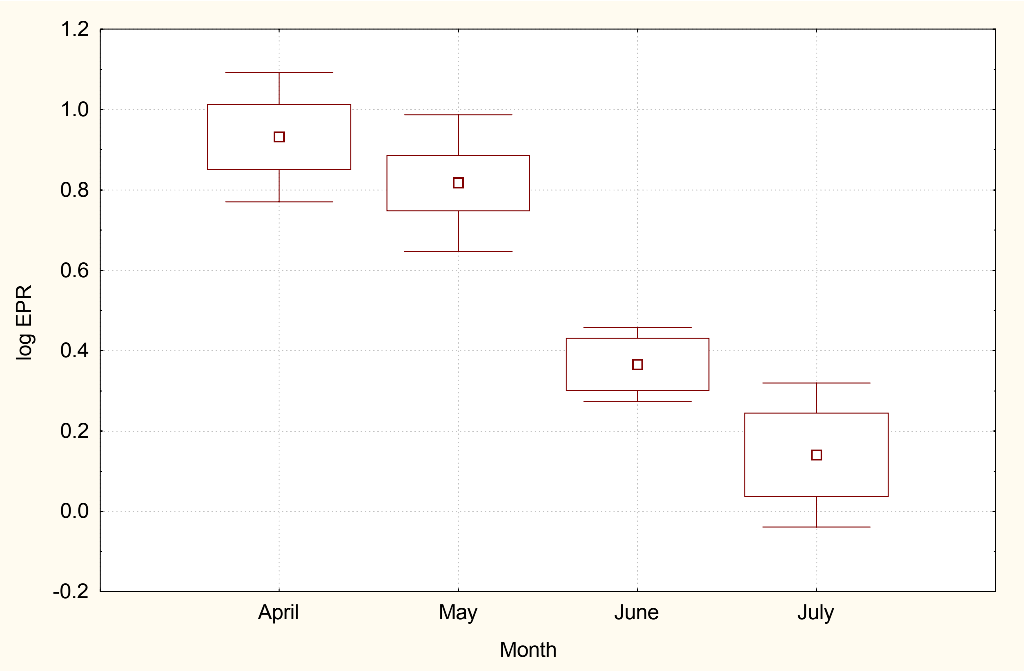


Fig. 3.1.15. Box-Whisker-Plot for copepod egg production (log EPR) vs. month for *Temora longicornis*; small squares – means, boxes – stand errors, and bars – standard deviations.

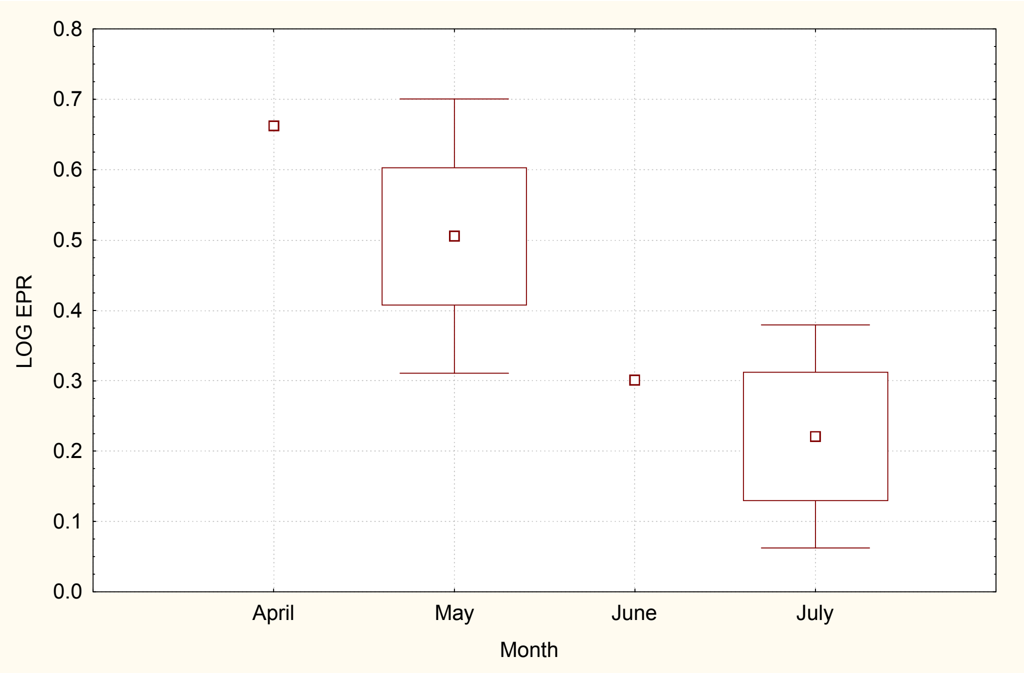


Fig. 3.1.16. Box-Whisker-Plot for copepod egg production (log EPR) vs. month for *Pseudocalanus elongatus*; small squares – means, boxes – stand errors, and bars – standard deviations.

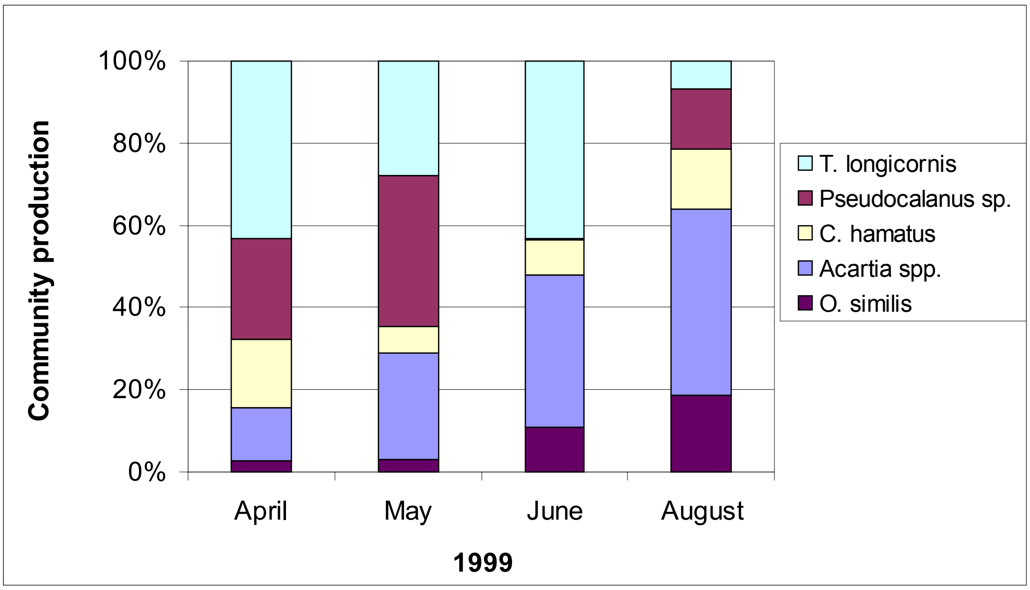


Fig. 3.1.17. Species composition of copepod community production in the Bornholm Basin in 1999.

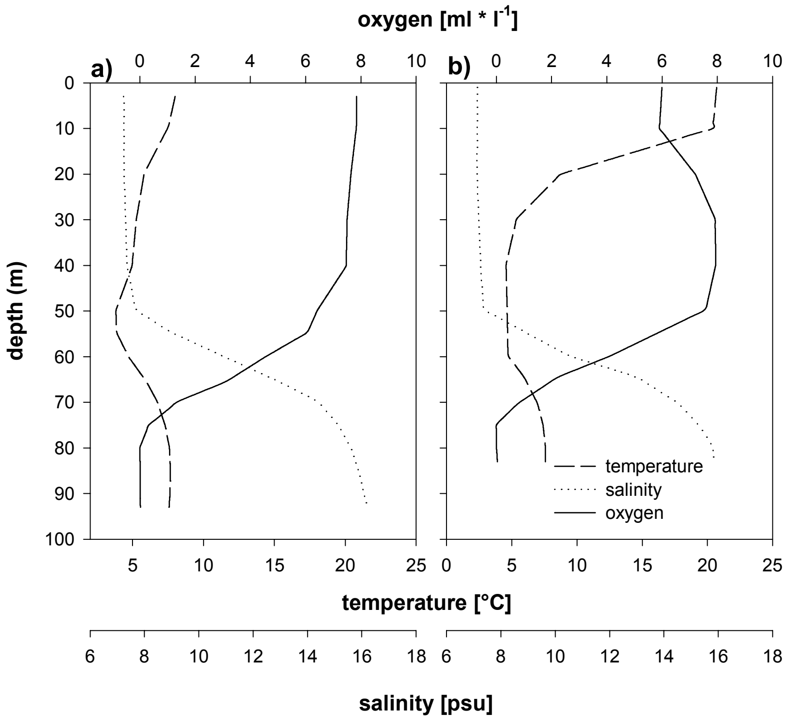
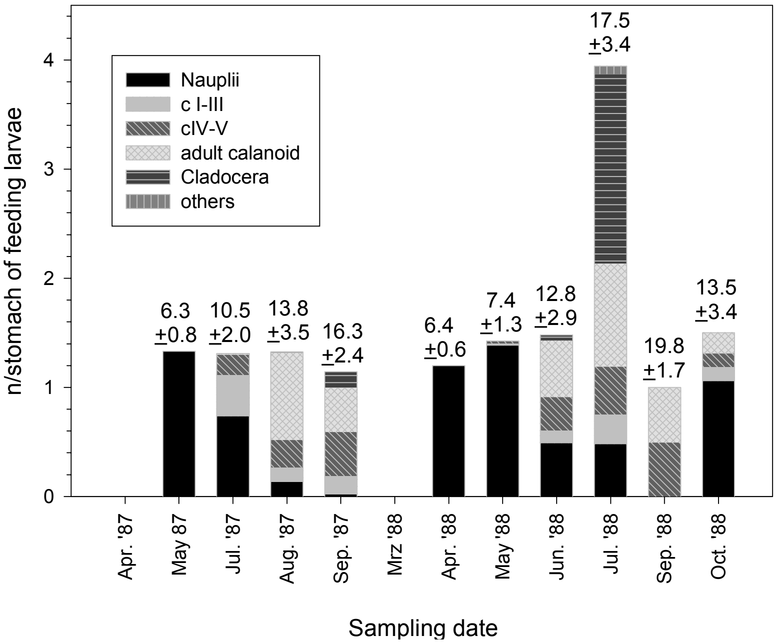
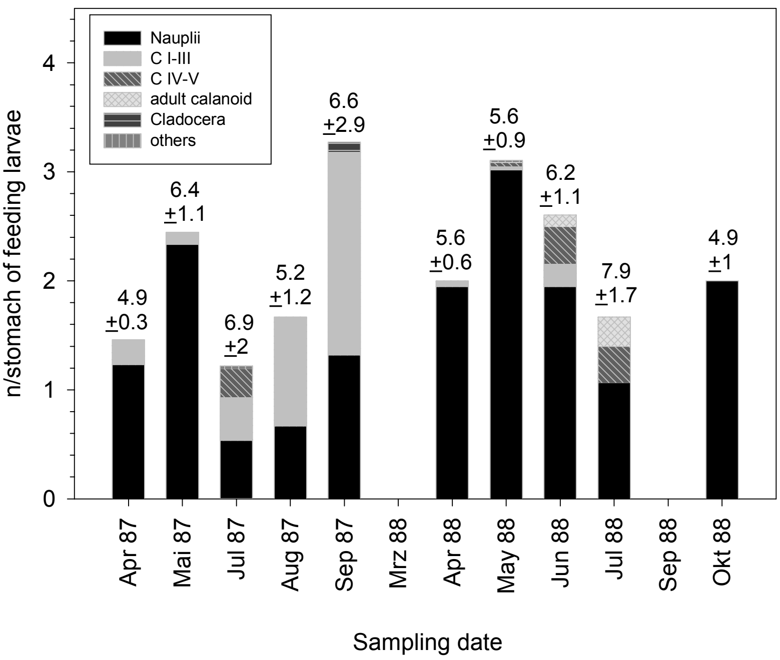


Fig. 3.1.18. Vertical profiles of oxygen, temperature and salinity in May 1999 (a) on station 23 and August 1999 (b) on station 16 in the Bornholm Basin.


Nauplii
c I-III
cIV-V
adult calanoid
Cladocera
others
n/stomach of feeding larvae
17.5
±3.4
6.3
±0.8
10.5
±2.0
13.8
±3.5
16.3
±2.4
6.4
±0.6
7.4
±1.3
12.8
±2.9
19.8
±1.7
13.5
±3.4
Apr. '87
May 87
Jul. '87
Aug. '87
Sep. '87
Mrz '88
Apr. '88
May '88
Jun. '88
Jul. '88
Sep. '88
Oct. '88
Sampling date


Nauplii
C I-III
C IV-V
adult calanoid
Cladocera
others
n/stomach of feeding larvae
4.9
±0.3
6.4
±1.1
6.9
±2
5.2
±1.2
6.6
±2.9
5.6
±0.6
5.6
±0.9
6.2
±1.1
7.9
±1.7
4.9
±1
Apr 87
Mai 87
Jul 87
Aug 87
Sep 87
Mrz 88
Apr 88
May 88
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Sep 88
Okt 88
Sampling date

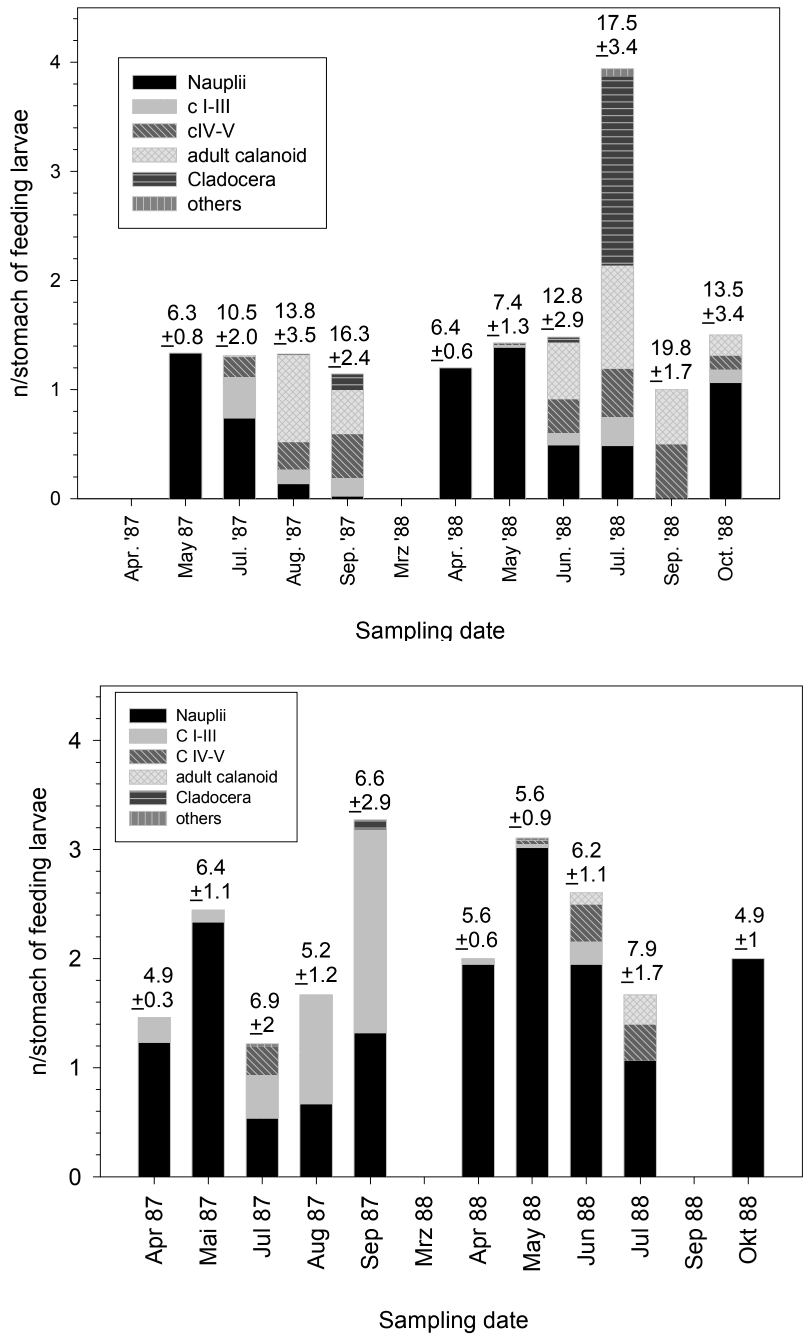


Fig. 3.1.19 Average diet composition (n/stomach of feeding larvae) over the investigated time period for sprat larvae (upper panel) and cod larvae (lower panel).

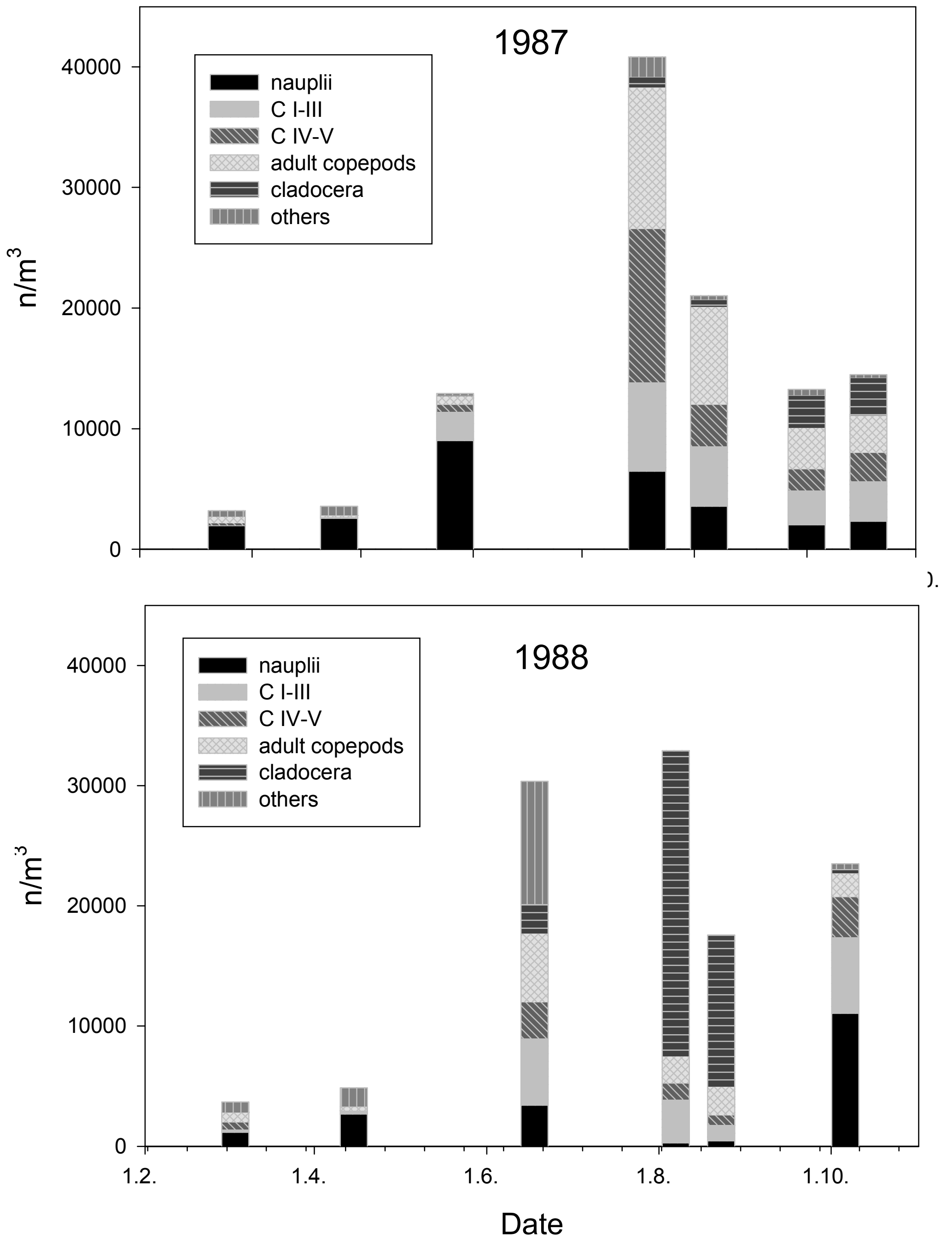
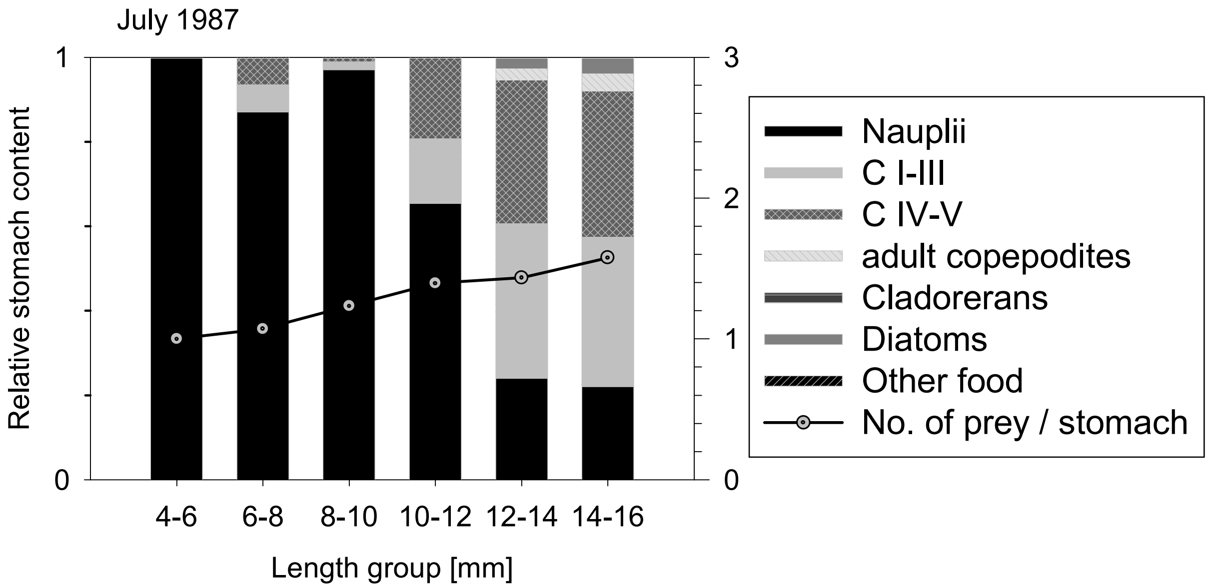


Fig. 3.1.20. Zooplankton abundance in the Bornholm Basin for 1987 (upper panel) and 1988 (lower panel).



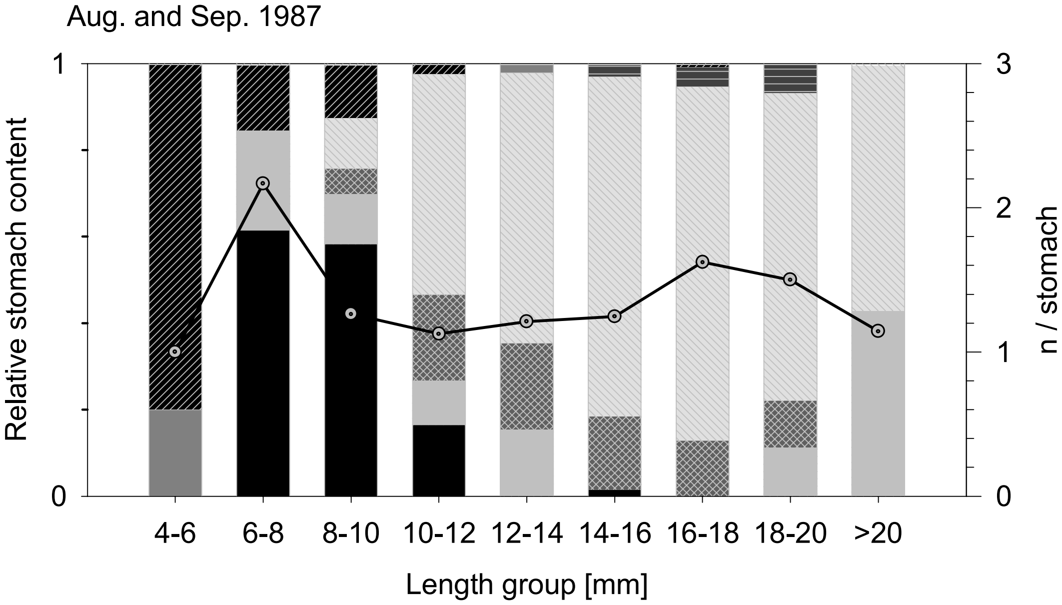


Fig. 3.1.21. Relative stomach content [% of numbers] and total stomach content [numbers per stomach] for 2 mm length classes of sprat larvae in 1987.

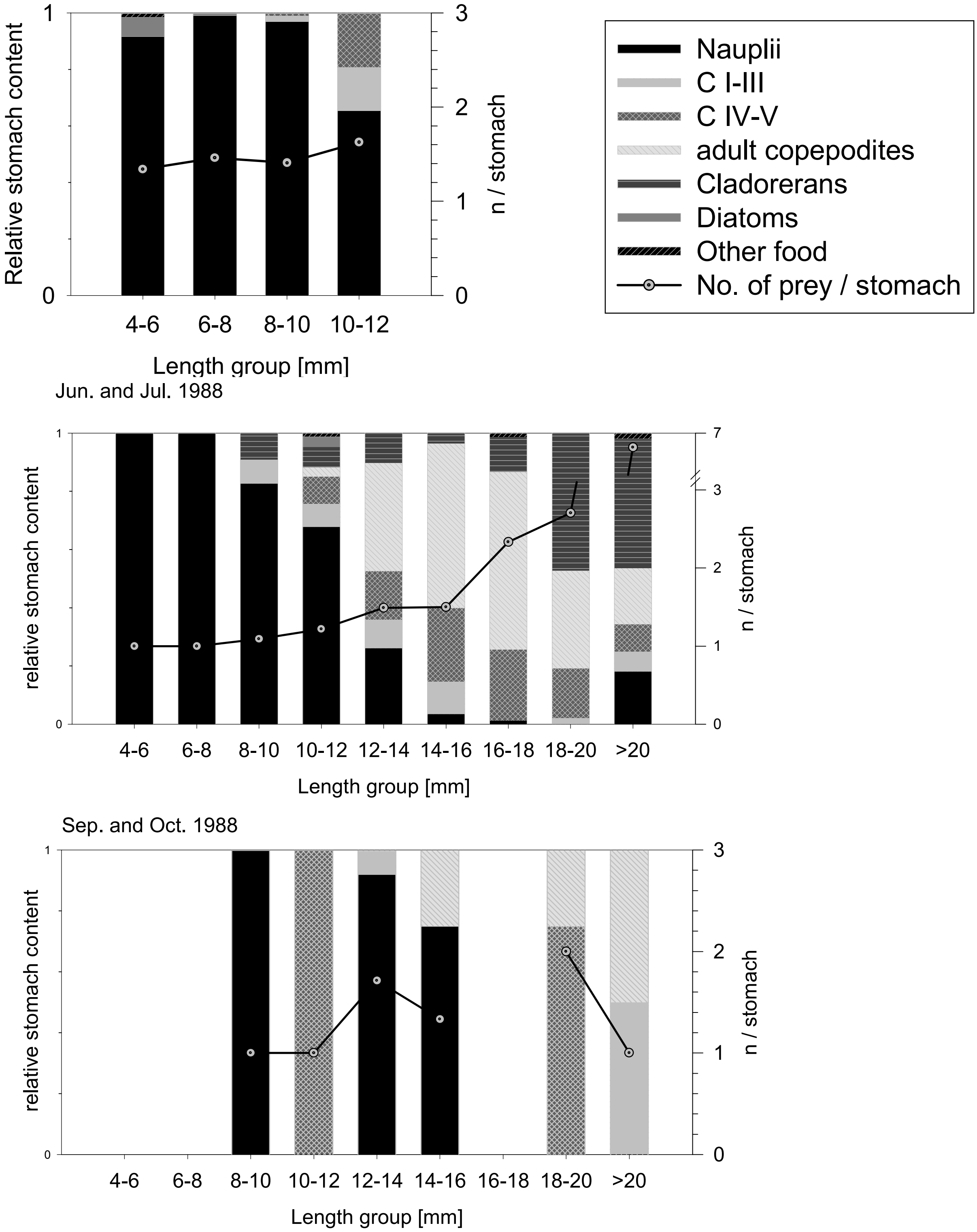
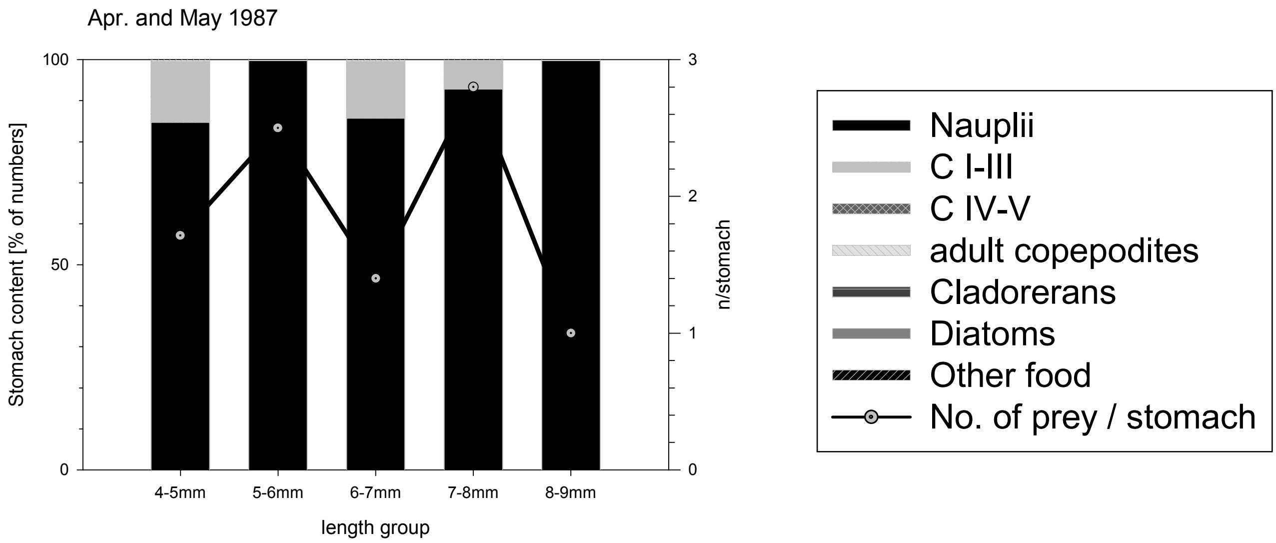


Fig. 3.1.22. Relative stomach content [% of numbers] and total stomach content [numbers per stomach] for 2 mm length classes of sprat larvae in 1988.



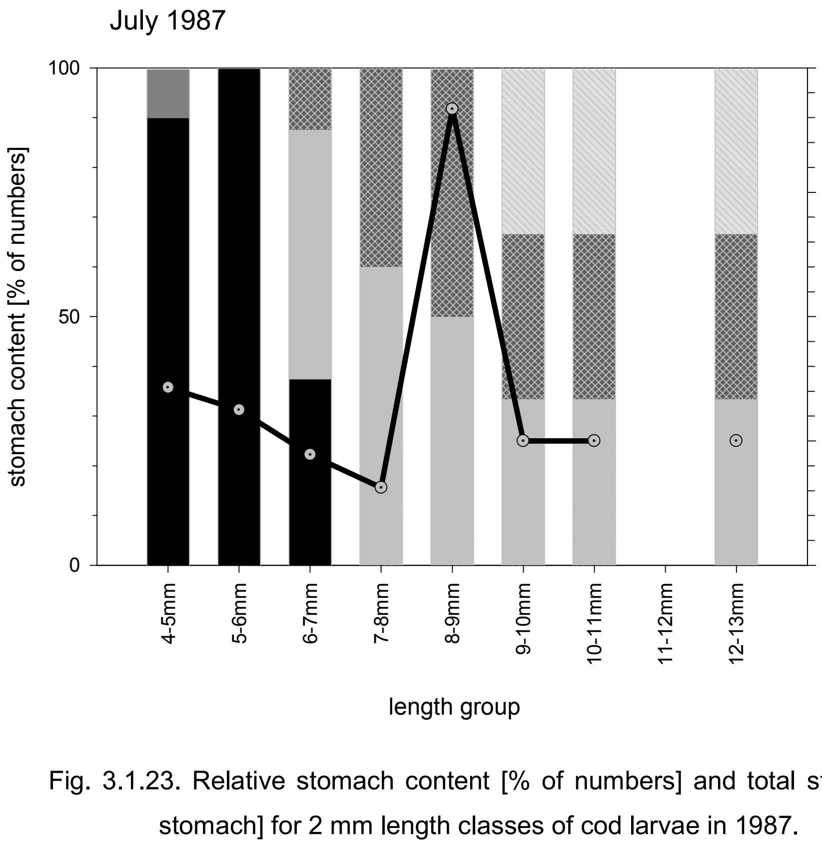


Fig. 3.1.23. Relative stomach content [% of numbers] and total stomach content [numbers per stomach] for 2 mm length classes of cod larvae in 1987.

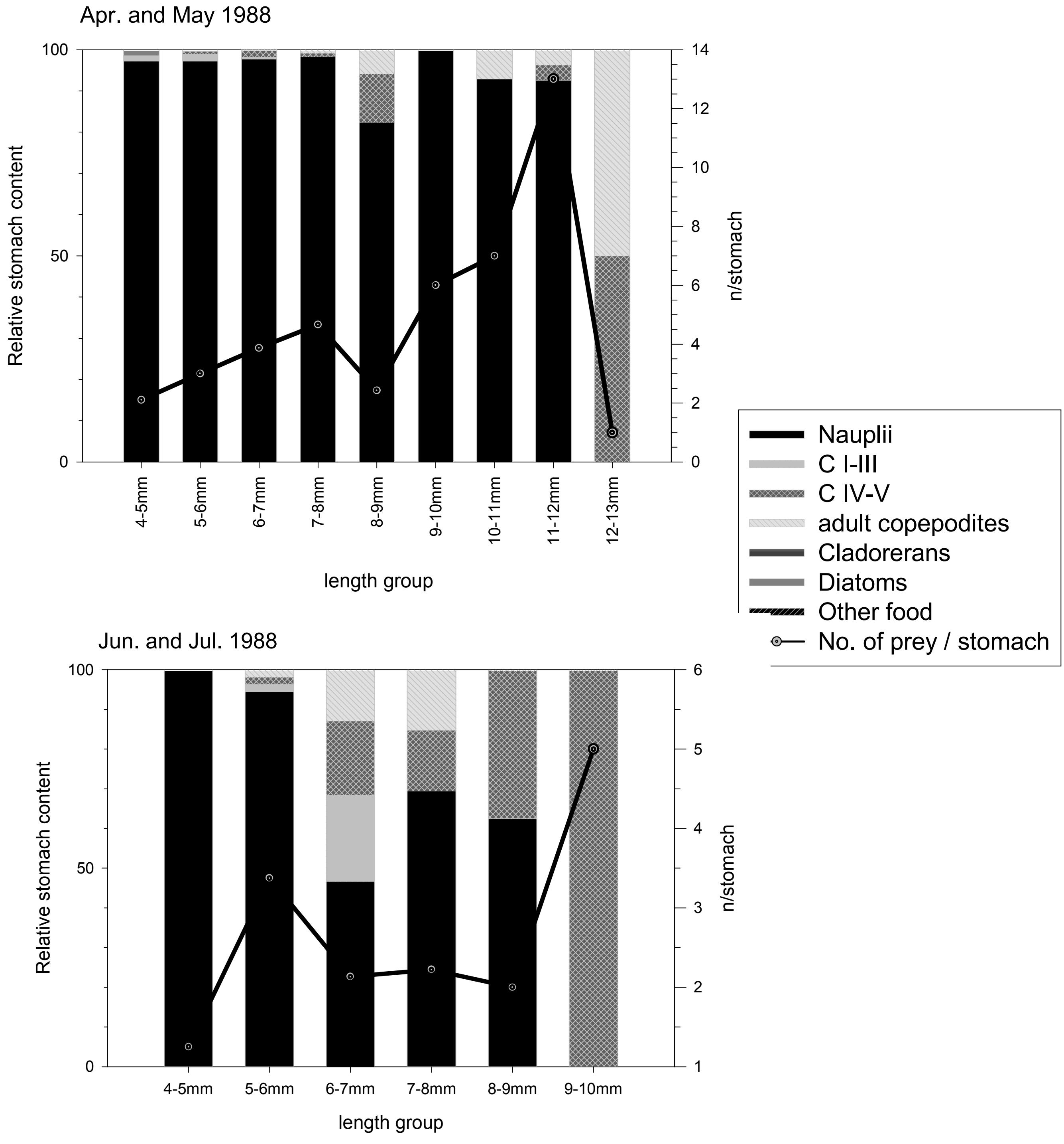


Fig. 3.1.24 Relative stomach content [% of numbers] and total stomach content [numbers per stomach] for 2 mm length classes of cod larvae in 1988.

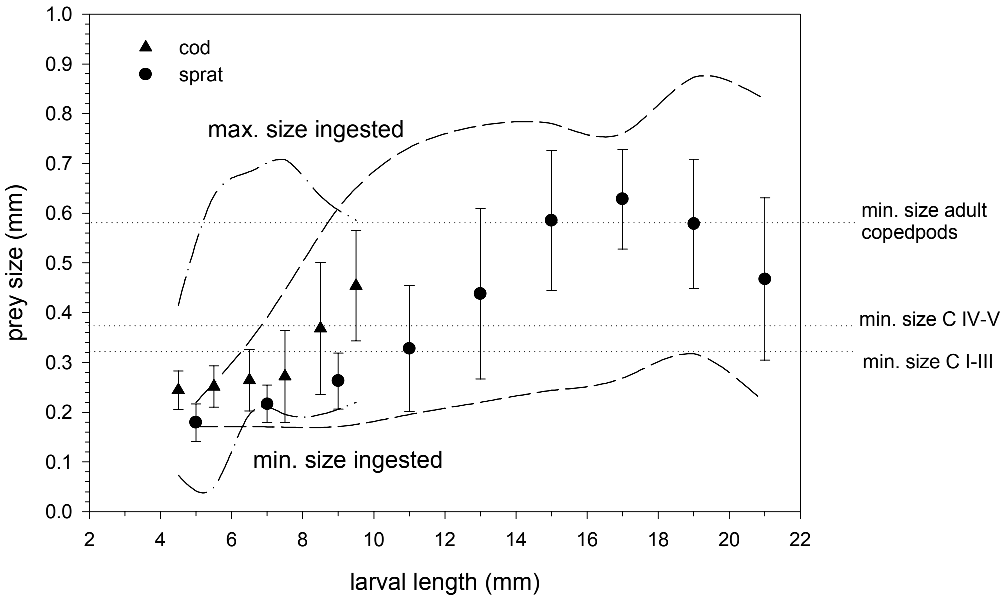


Fig. 3.1.25. Mean, minimum and maximum ingested prey lengths for different sized sprat and cod larvae. Error bars indicate the standard deviation of the mean prey length, dotted lines show the minimum size of different prey organisms in the sea.

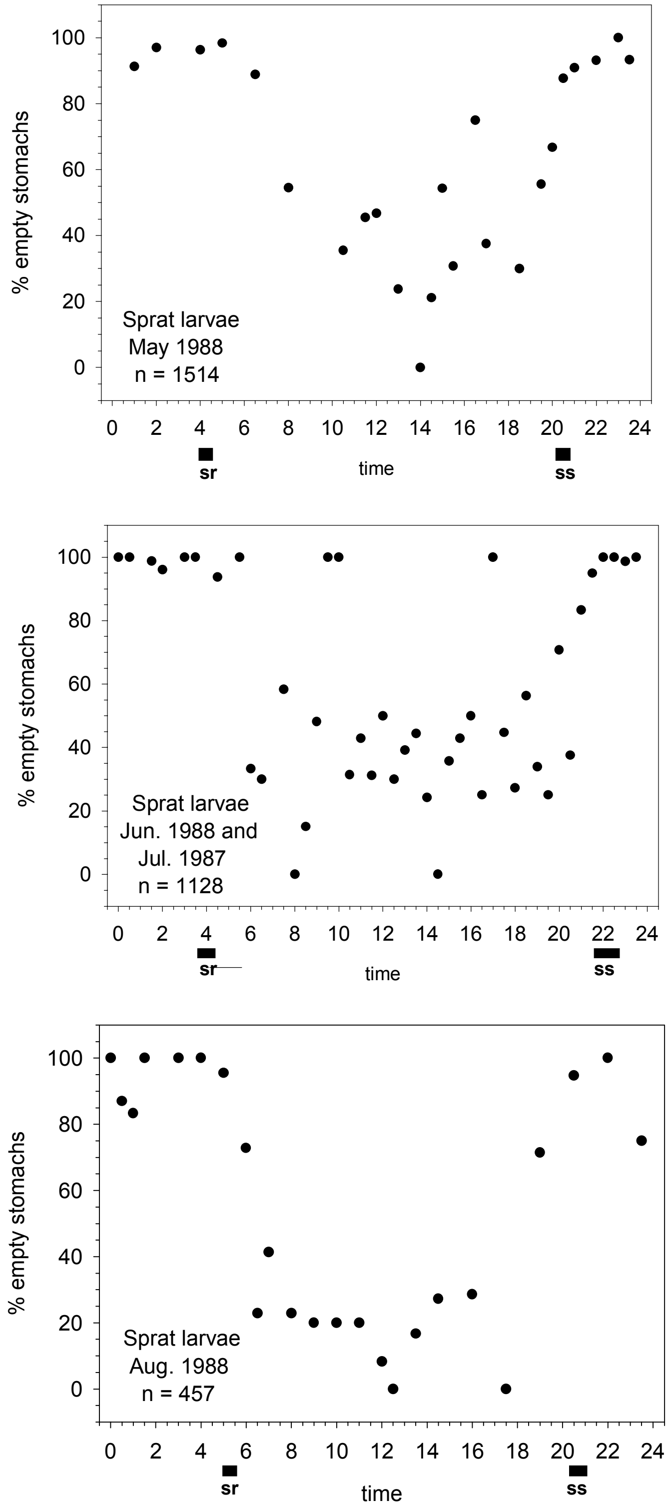


Fig. 3.1.26. Percentage of empty sprat larvae stomachs for different times of the day. Black bars indicate the time of sunrise (sr) and sunset (ss).

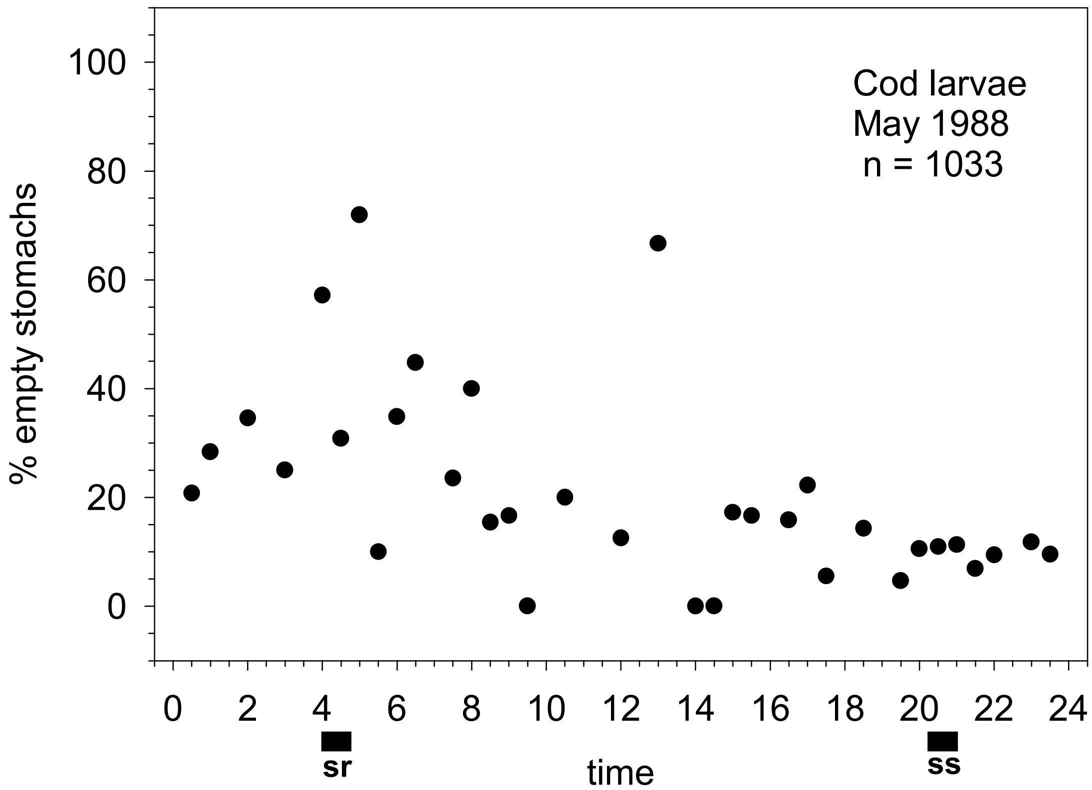


Fig. 3.1.27. Percentage of empty cod larvae stomachs for different times of the day. Black bars indicate the time of sunrise (sr) and sunset (ss).

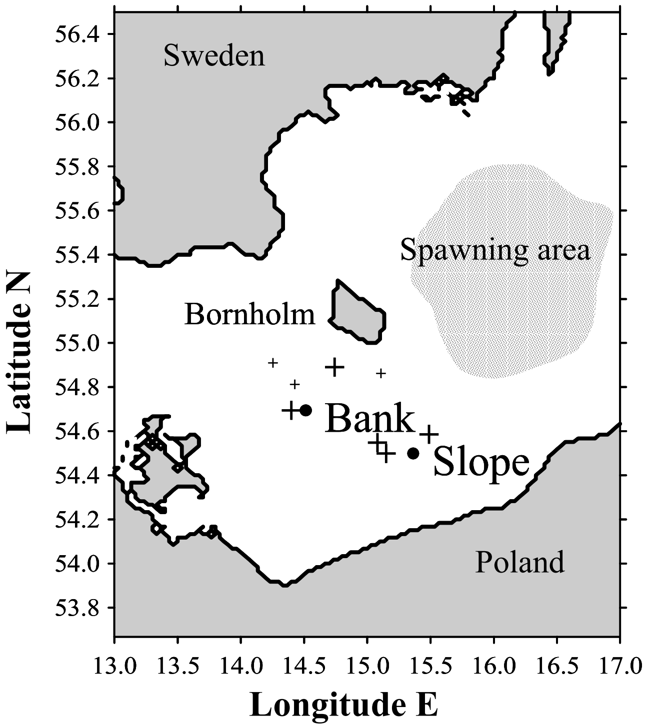
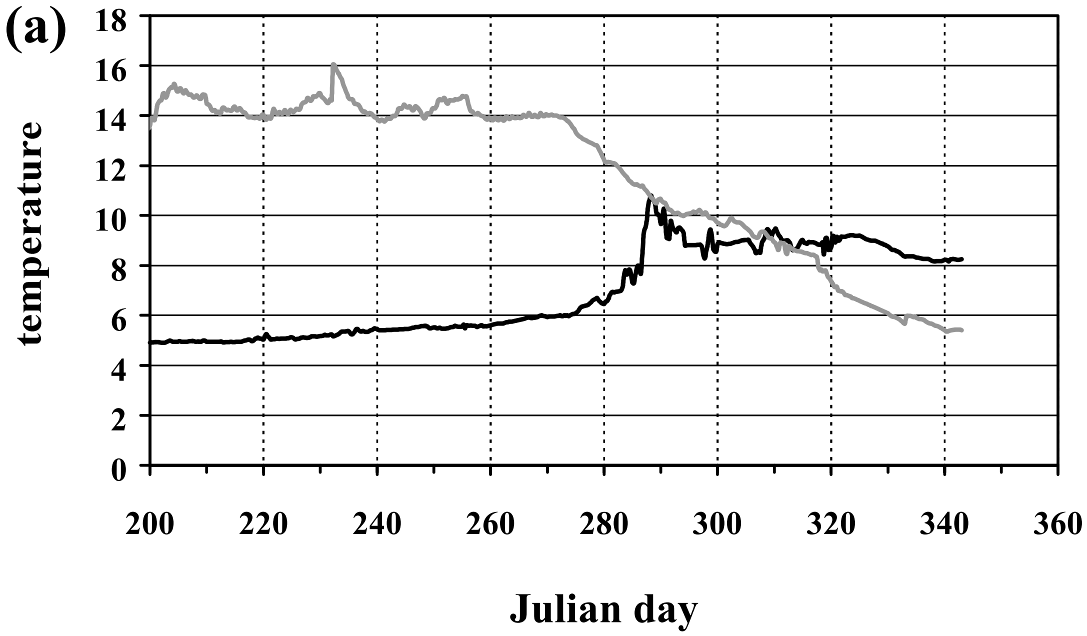


Fig. 3.1.28. Map of the Baltic Sea, with the sampling stations from the two cruises. Symbols: (•)= December “DANA” cruise marked as Slope and Bank, (+)= November “Solea” cruise, where large symbols signify >2 fish, small symbols= 2 fish. Axis units in decimal numbers..



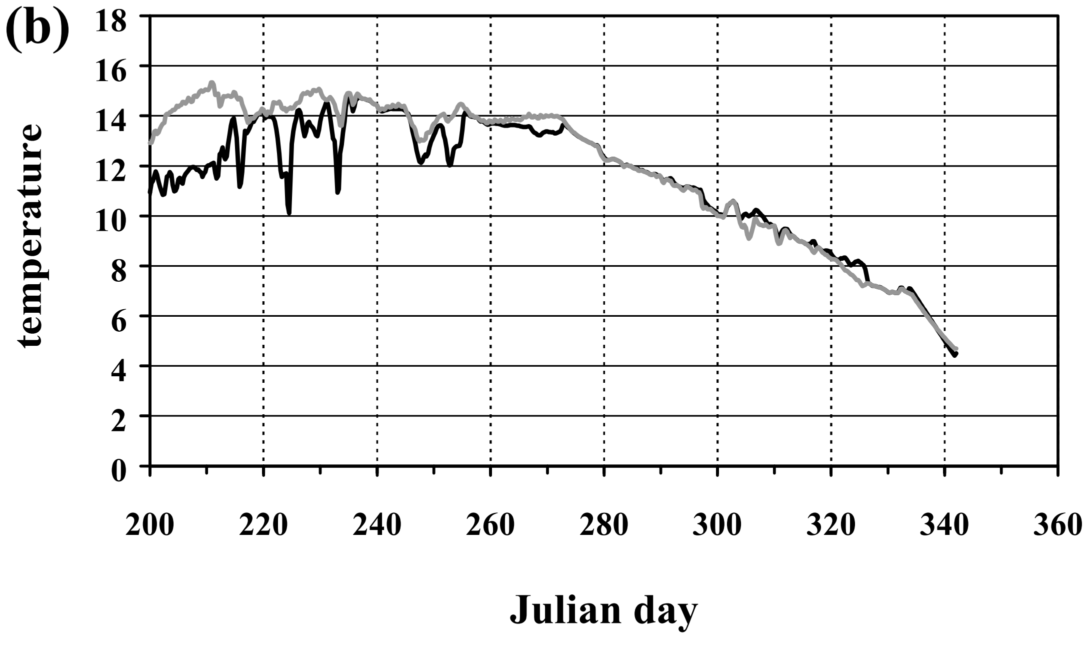
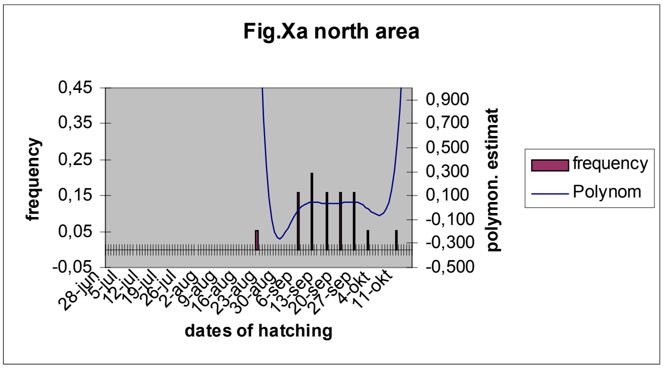
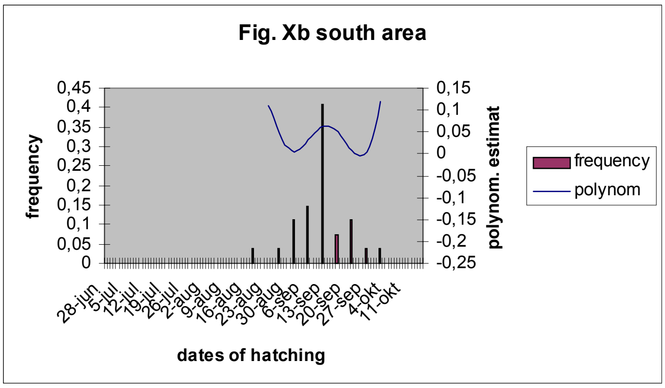
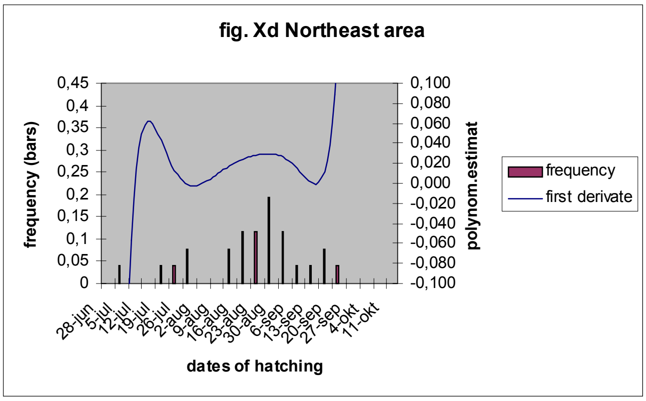


Fig. 3.1.29. Temperature development over time in the surface layer and near the bottom of two localities on Rønne Bank, Baltic Sea (**a**) Slope and (**b**) Bank. Black lines: 0.5 m above bottom, grey lines: 1.5 m below surface. In (**b**) temperatures after day 334 extrapolated to observed values on day 342.







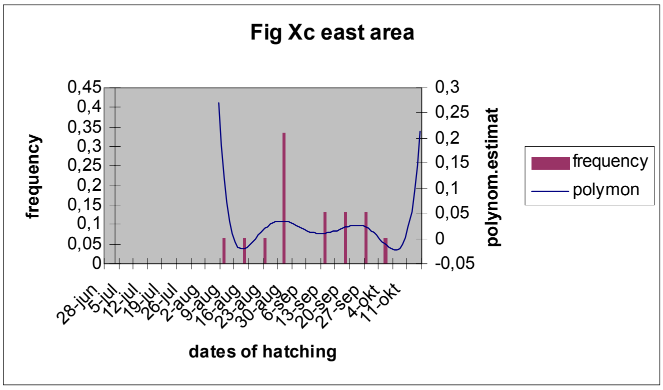


Fig. 3.1.30. Hatchdates distribution from the juvenile cod that was caught in the northern, southern, eastly and Northeasterly settling areas of the Bornholm Basin. The bars indicate the frequency of the different Hatchdates. Lines illustrate the first derivate of the 8 degree polynomial regression analysis that were applied to the cumulated hatchdates distributions. The central settling areas was not included due to low numbers of sampled fish.

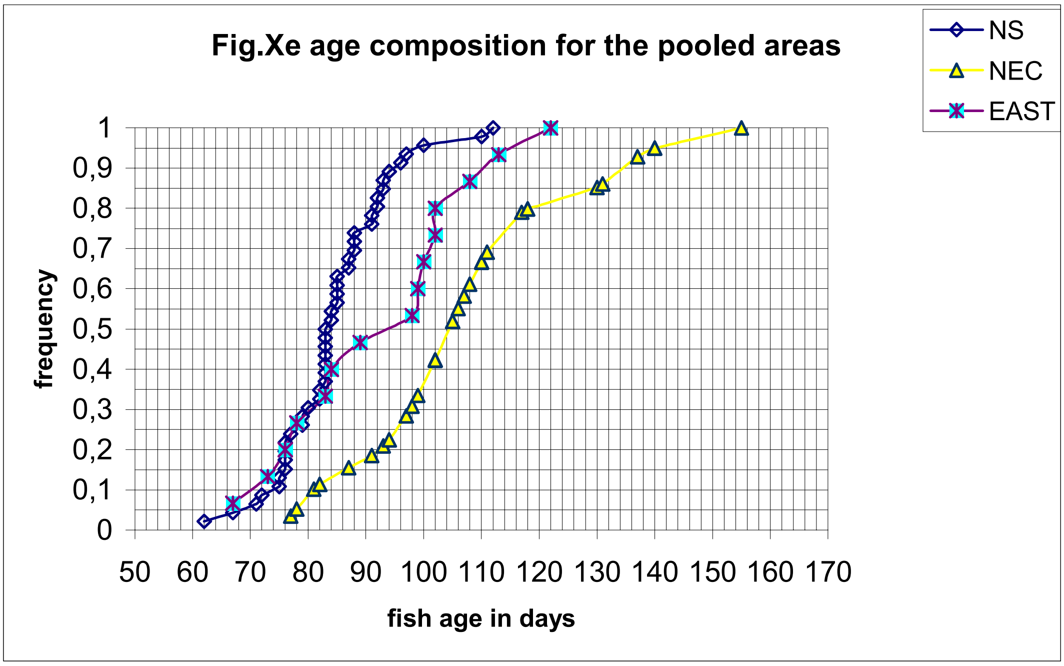


Fig. 3.1.31. The cumulative age frequencies of the NS- group, the NEC-group and the E-group plotted against age. Significant differences was observed between the NS-group and the NEC-group($P<0.005$, Kolomogorov-Smirnoff test), and between the EAST group and both the NS-group and the NEC-group($P<0.05$, Kolomogorov-Smirnoff test).

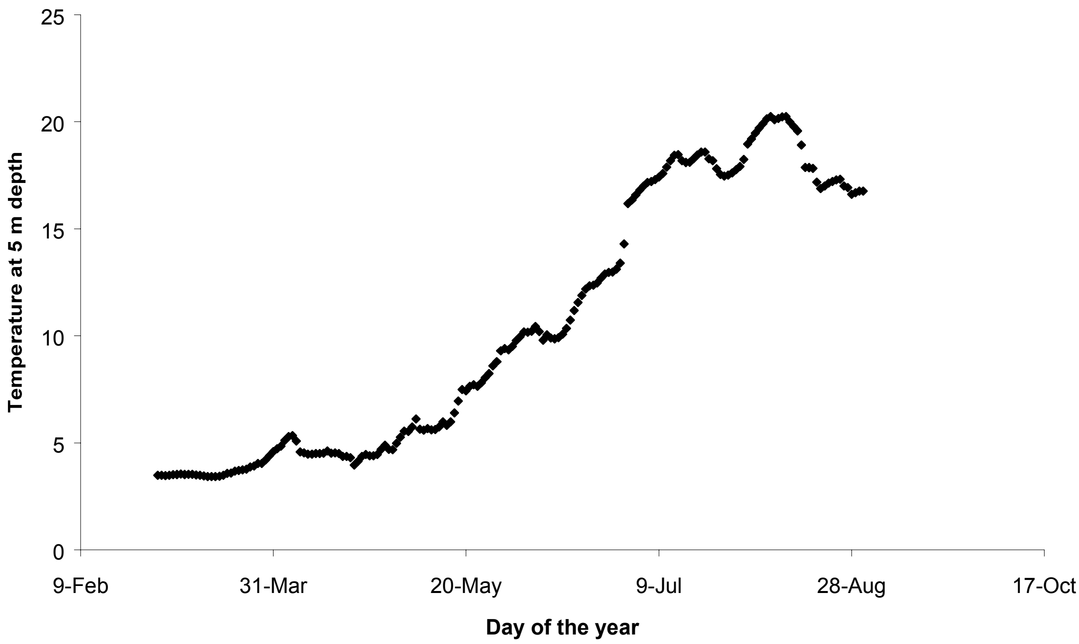
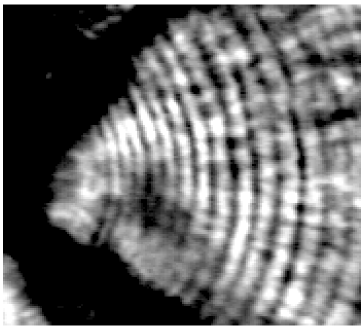


Fig. 3.1.32. Average temperature (˚C) over the first 10 m depth measured over the sprat-spawning season in 1999 used to develop a method to estimate date of first primary increment formation.



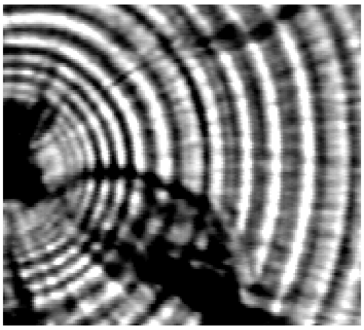


Fig. 3.1.33. Otolith microstructure of two otoliths forming first primary increment formation at 10 ºC (left) and 18 ºC (right) of temperature respectively.

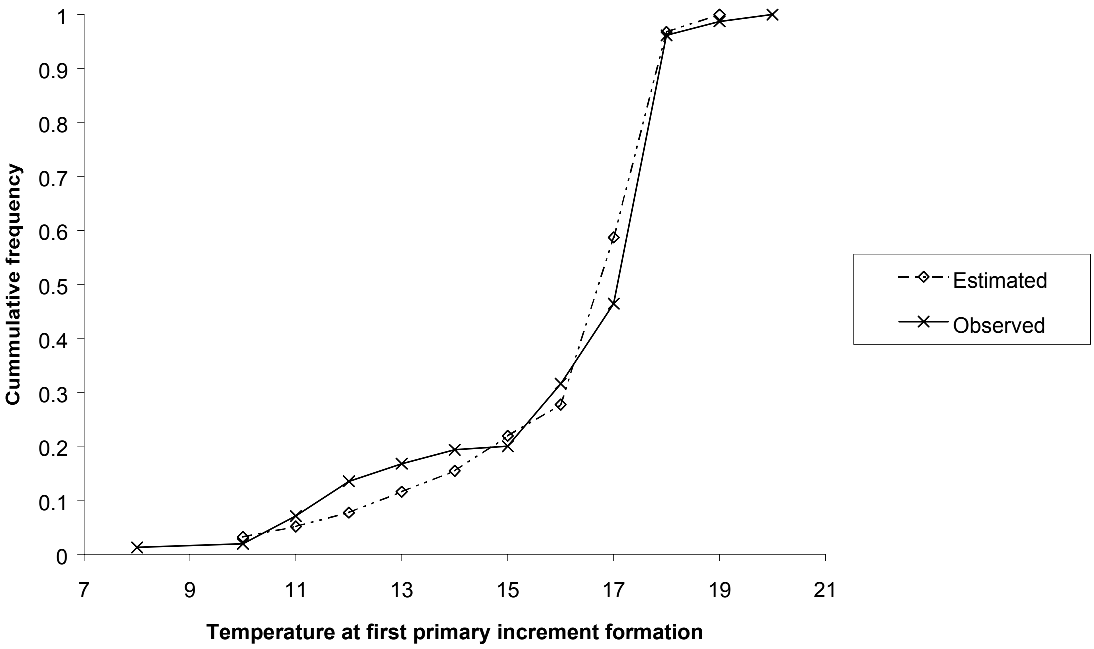


Fig. 3.1.34. Comparison between estimated and observed temperature at first primary increment formation in larvae caught over 1999.

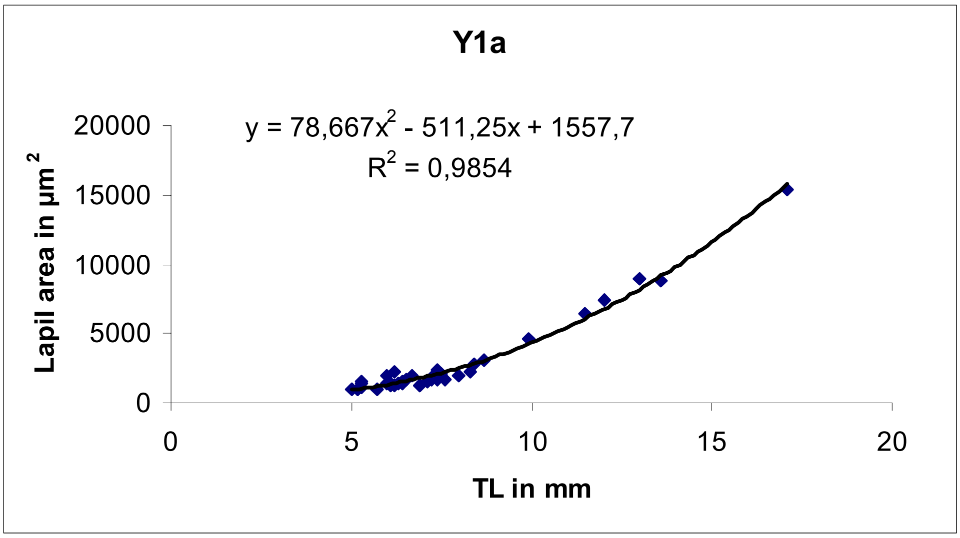


Fig. 3.1.35. Fish length plotted against lapillus area. Regression analysis indicated strong correlations: Oto.area=78,667*TL^2-511,25*TL+1557,7 ; r^2=0,985.

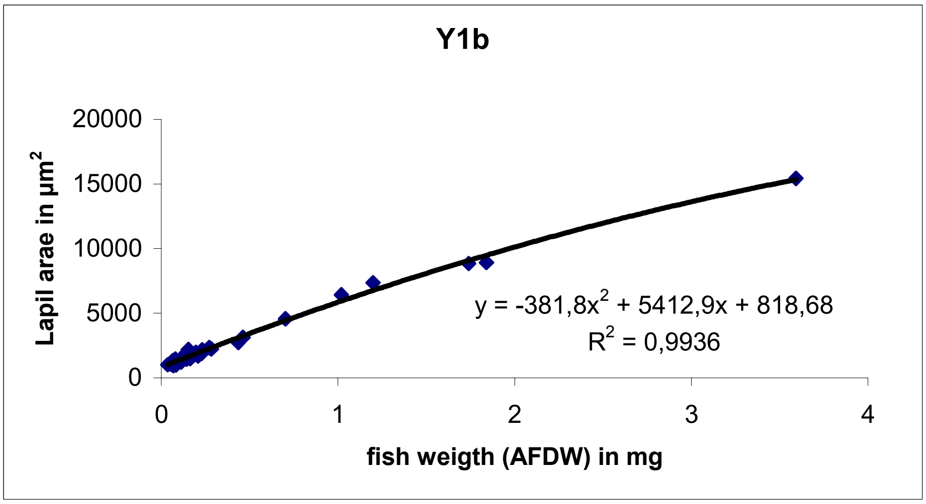


Fig. 3.1.36. Fish weight plotted against lapillus area. Regression analysis indicated strong correlations: Oto.area=381,8*TL^2-5412,9*TL+818,687 : r^2=0,994.

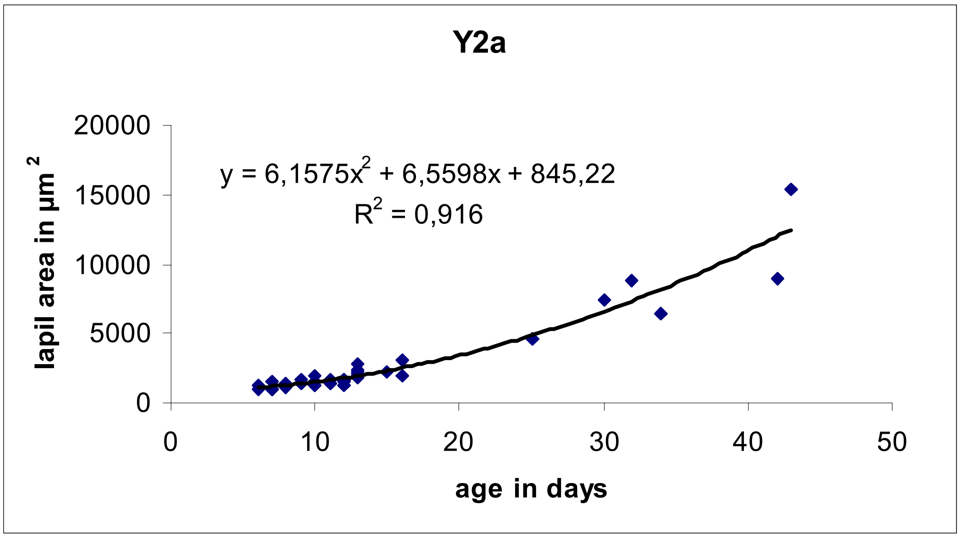


Fig. 3.1.37. Fish age plotted against lapillus area. Regression analysis indicated strong correlations: Oto.area=6,1575* age^2+ 6,56*age +845,22: r^2=0,916.

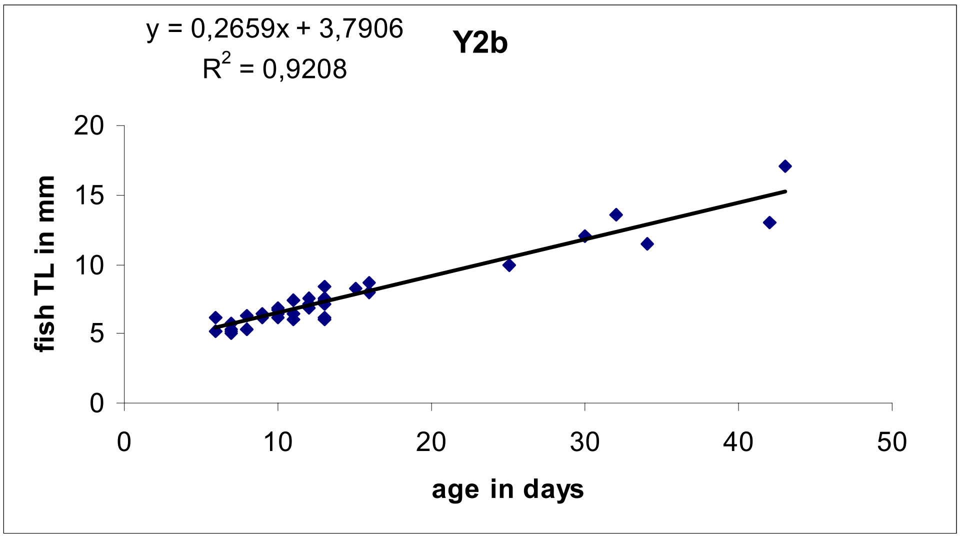


Fig. 3.1.38. Fish age plotted against fish length. Regression analysis indicated strong correlations: Oto.area=0,266* TL +3,79: r^2=0,921.

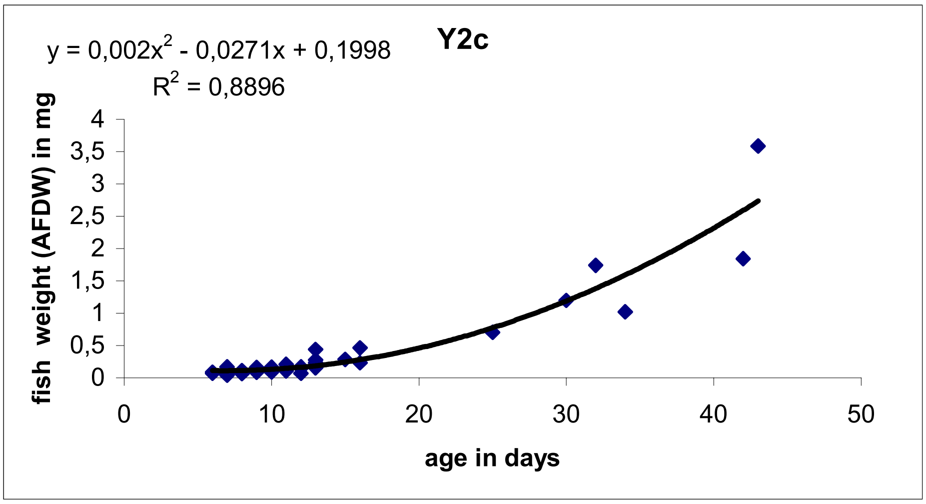


Fig. 3.1.39. Fish age plotted against fish alcohole free dry weigth. Regression analysis indicated strong correlations: fish weigth (AFDW)=0,002* TL +3,79; r^2=0,89.

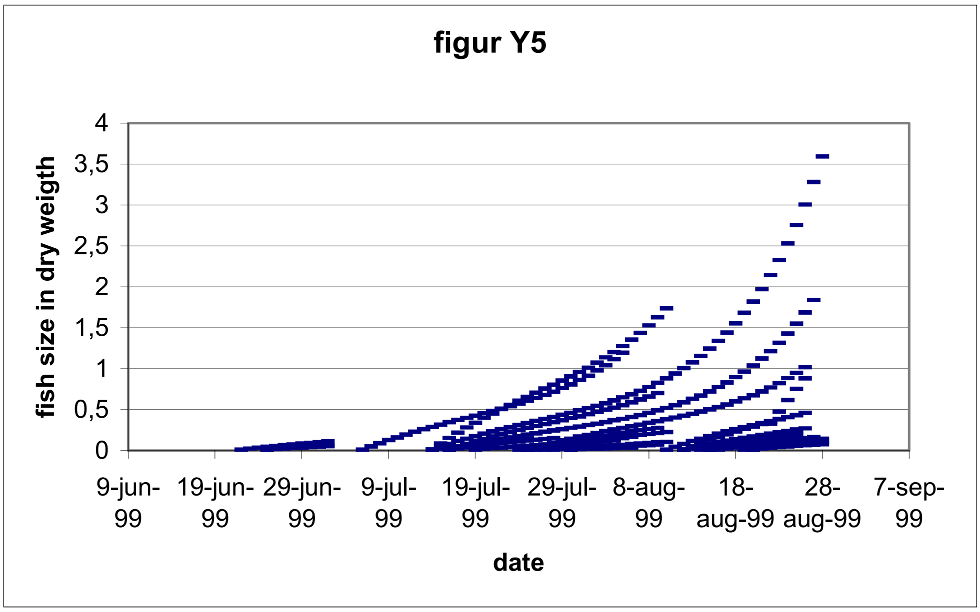


Fig. 3.1.40. Estimated fish growth trajectories from the TCM. The figure shows individual growth trajectories for the model that expresses the otolith growth as an allometrical funtion of somatic growth (model 4). Each point represents a size-at-date for the individual fish.

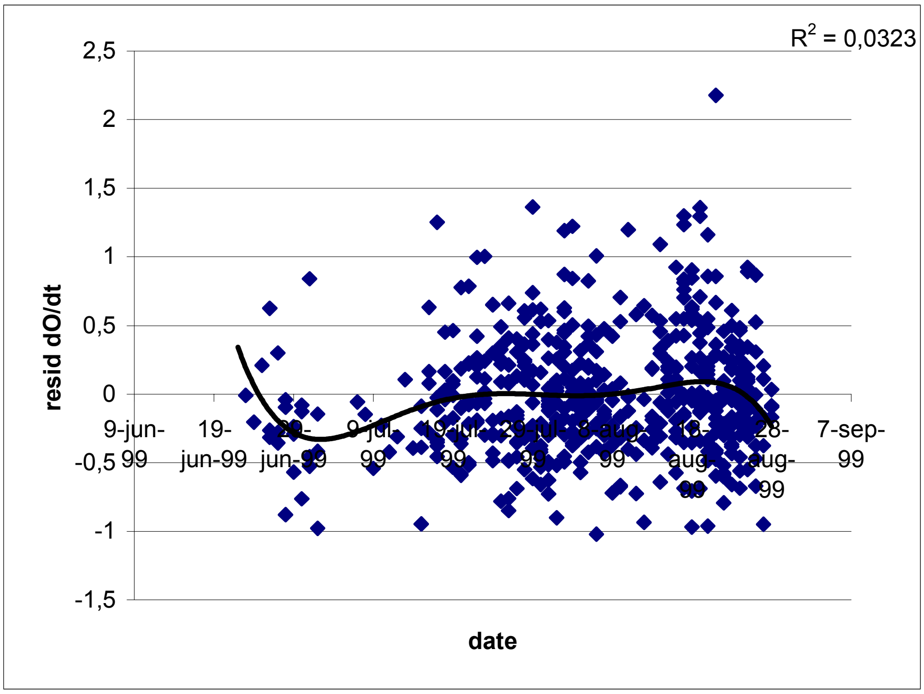
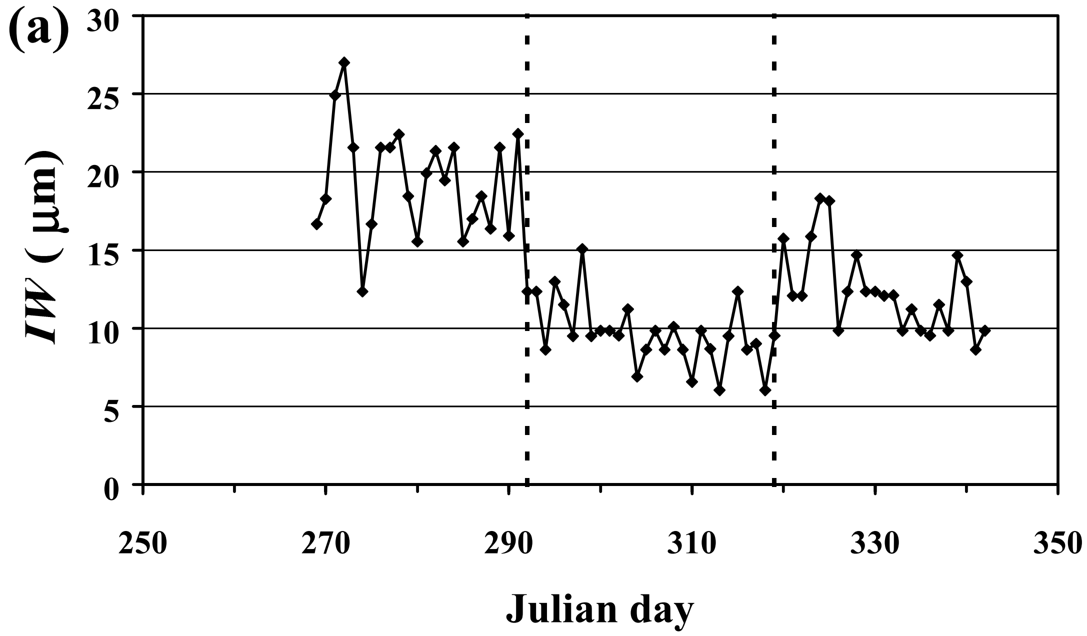


Fig. 3.1.41. Residuals from the regression between estimated and observed otolith growth for the otolith growth model 4. Polynomial regression showed a weak correlation with r^2=0,0323.



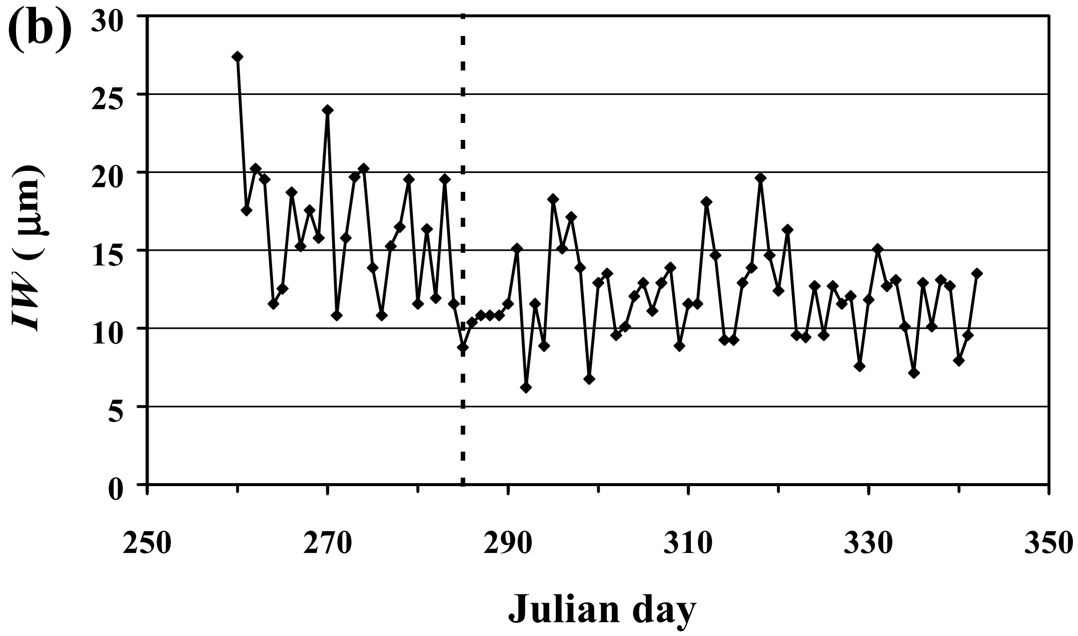
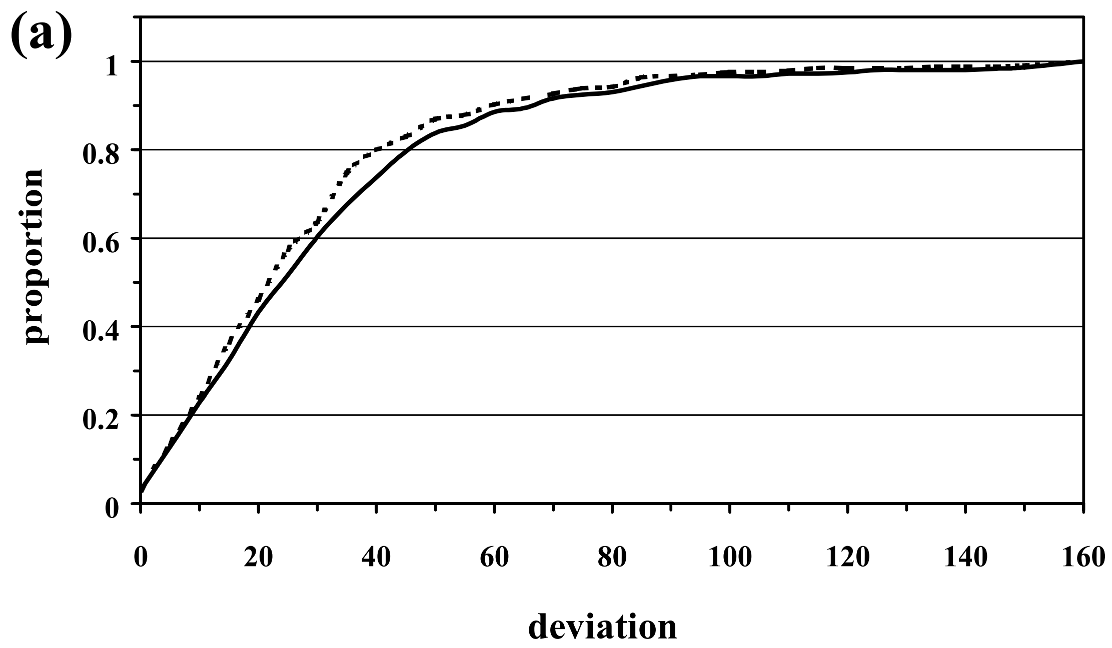
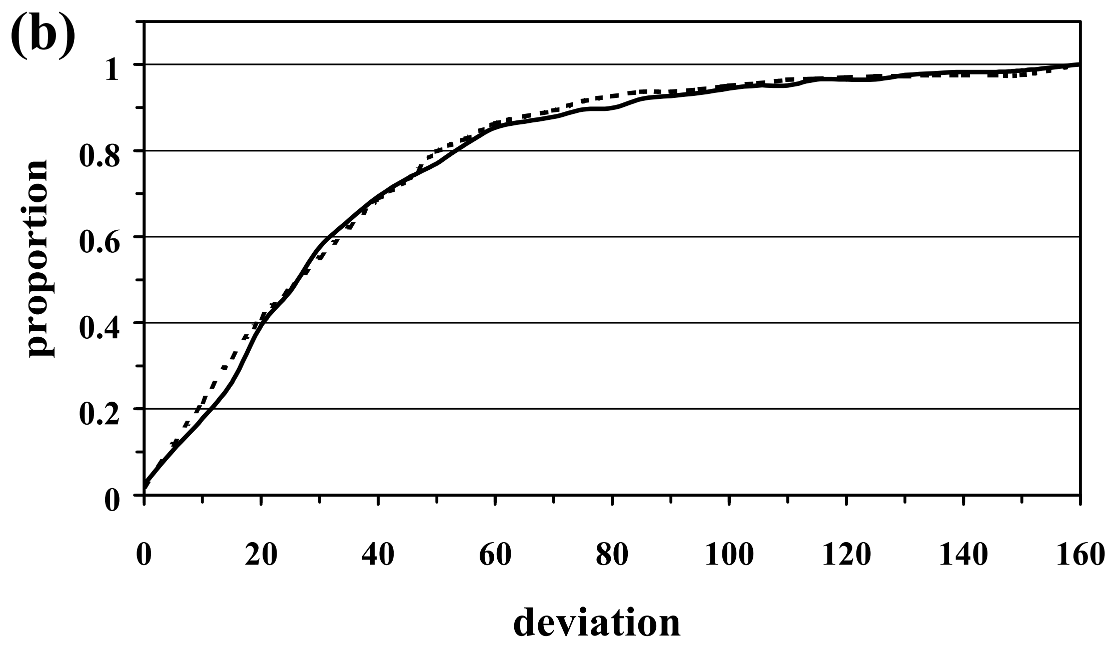
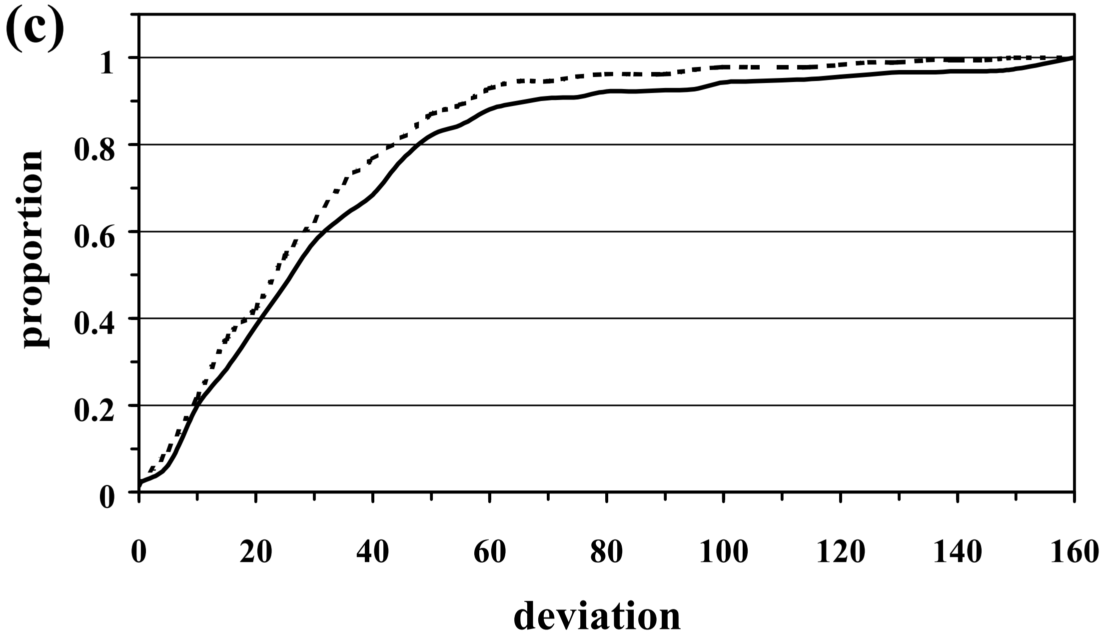


Fig. 3.1.42. Examples of otolith increment width (*IW*) development over time of juvenile cod caught on (**a**) Slope and (**b**) Bank. Vertical broken lines indicate change in increment width pattern.


(a)
proportion
1
0.8
0.6
0.4
0.2
0
0
20
40
60
80
100
120
140
160
deviation


(b)
proportion
1
0.8
0.6
0.4
0.2
0
0
20
40
60
80
100
120
140
160
deviation



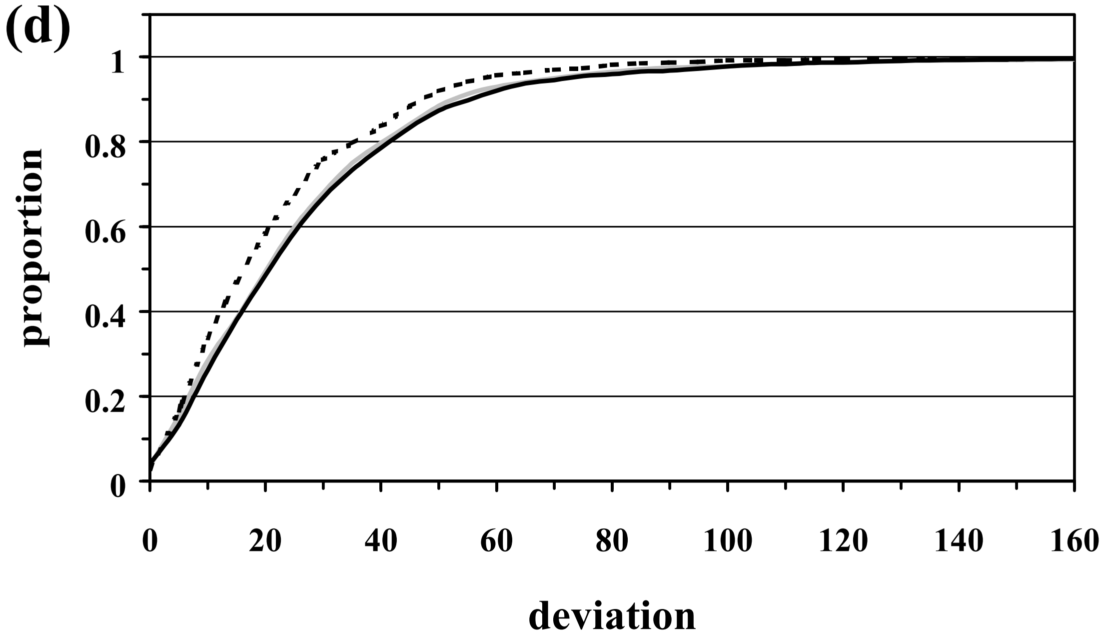


Fig. 3.1.43.The proportion of deviation between consecutive increments widths. (a), (b) and (c): Experimental samples, where (a) 5 °C, (b) 10 °C and (c) 15 °C, broken lines: low food, solid line: high food treatment. (d) Field samples, where broken black line: November sample, solid black line: slope, solid grey line: bank

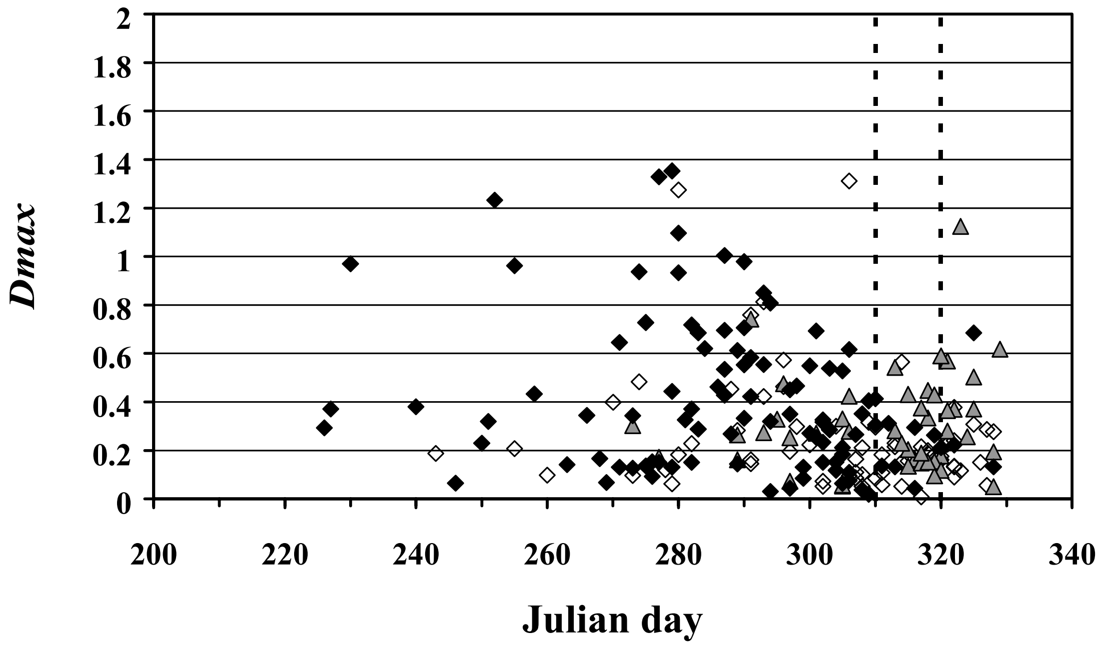


Fig. 3.1.44. The magnitude of change in increment width, calculated as $Dmax_j$= absolute value of AVERAGE(IW_{i-10} to IW_i)- AVERAGE (IW_i to IW_{i+10}). Vertical broken lines indicate time of thermocline turnover. Data points: ◆ : transition from pelagic to demersal, ◇ : pattern change in demersal stage

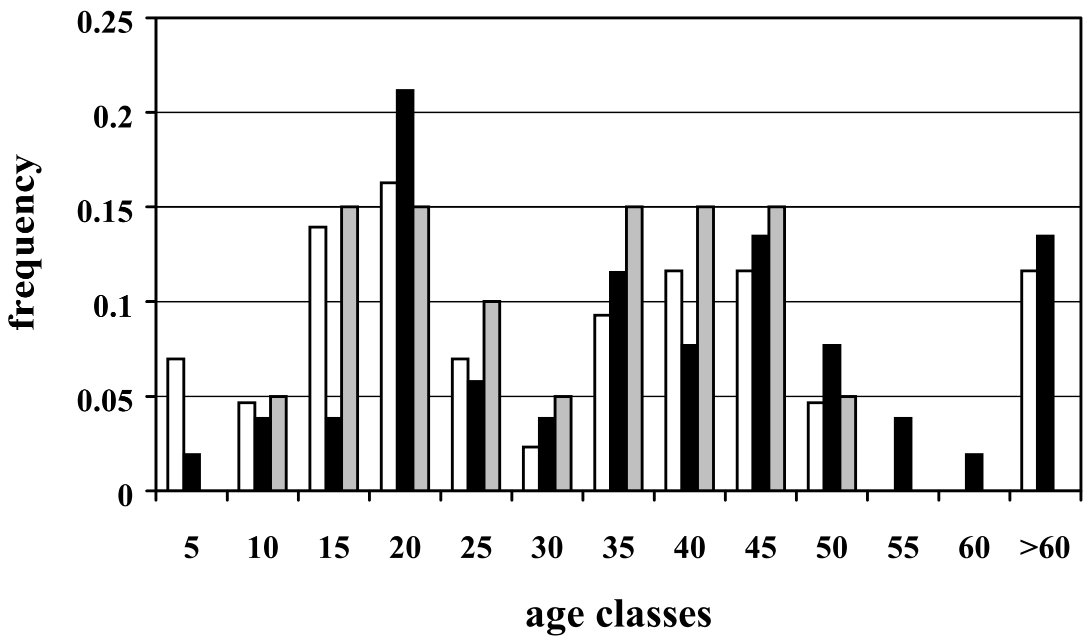


Fig. 3.1.45. Frequency distributions of fish age from the secondary growth centre to the edge at capture of the November sample (grey columns), and the December samples, back-calculated to the date of the November sample (black columns: Slope, white columns: Bank).

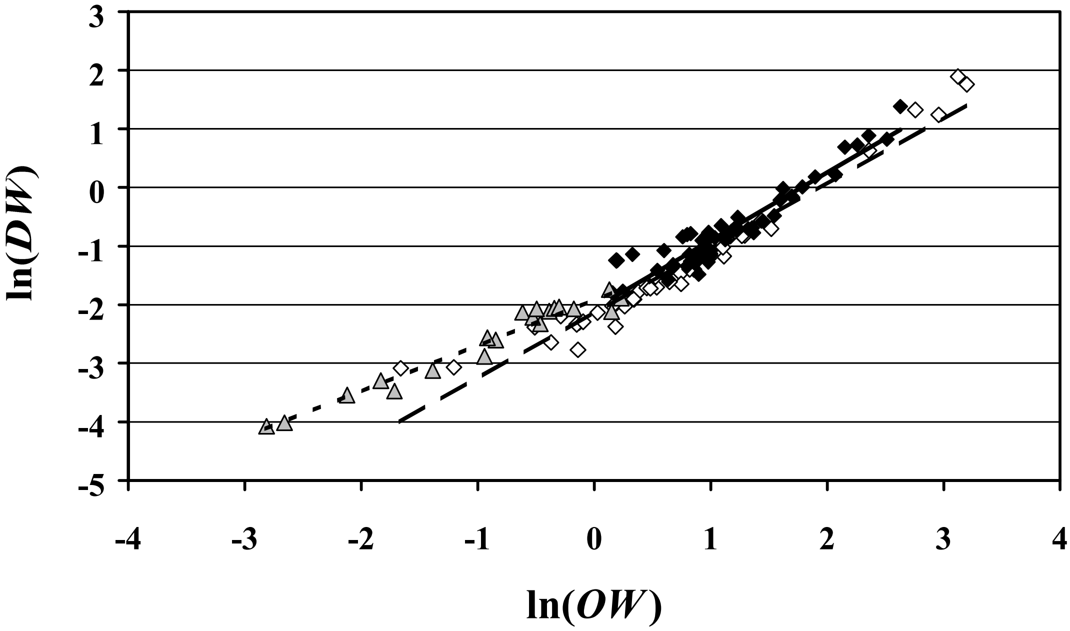


Fig. 3.1.46. Relationship between fish dry weight (g) and otolith weight (mg). Data points: ▲ : pelagic stage, ◇ : Bank, ◆ : Slope; Regression lines: dotted line: Pelagic stage, ln(*DW*)= -1.9108+0.7846·ln(*OL*), r^2= 0.96, p=<0.001; solid line: Slope, ln(*DW*)= -2.3251+1.4767·ln(*OL*), r^2= 0.91, p<0.001; broken line: Bank, ln(*DW*)= -2.1426+1.0948·ln(*OL*), r^2= 0.95, p<0.001

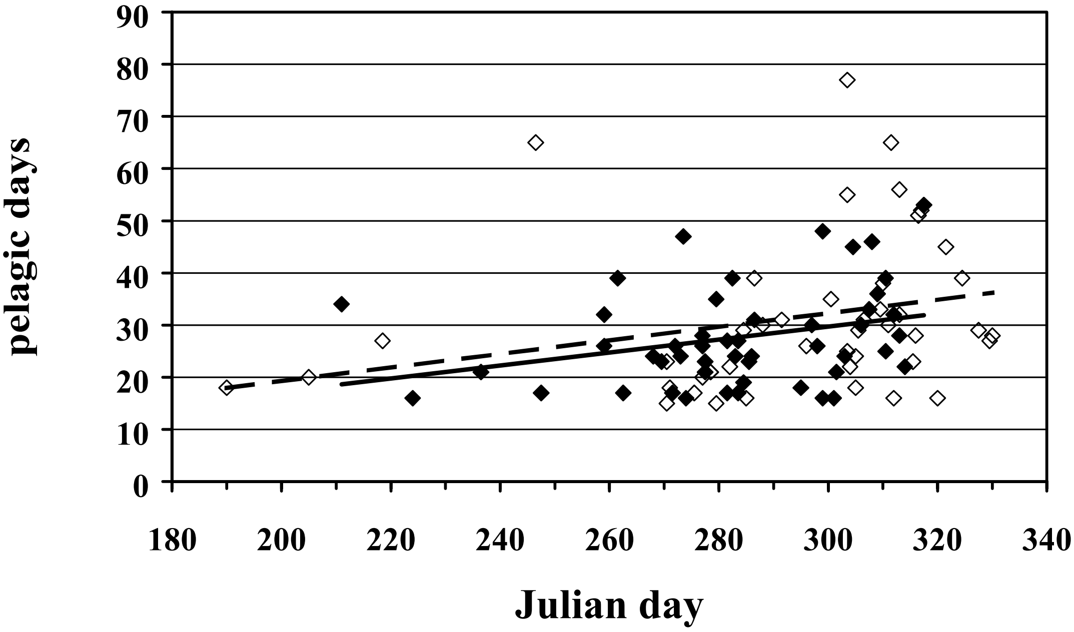


Fig. 3.1.47. Days spent in the pelagic stage in relation to average date of formation. Data points: ◆ : slope, ◇ : bank; Regression lines: solid: Slope, days in I_1= -7.562+0.124·*julian day*, r^2= 0.096, p= 0.026; broken: Bank, days in I_1= -7.441+0.132·*julian day*, r^2= 0.054, p= 0.043

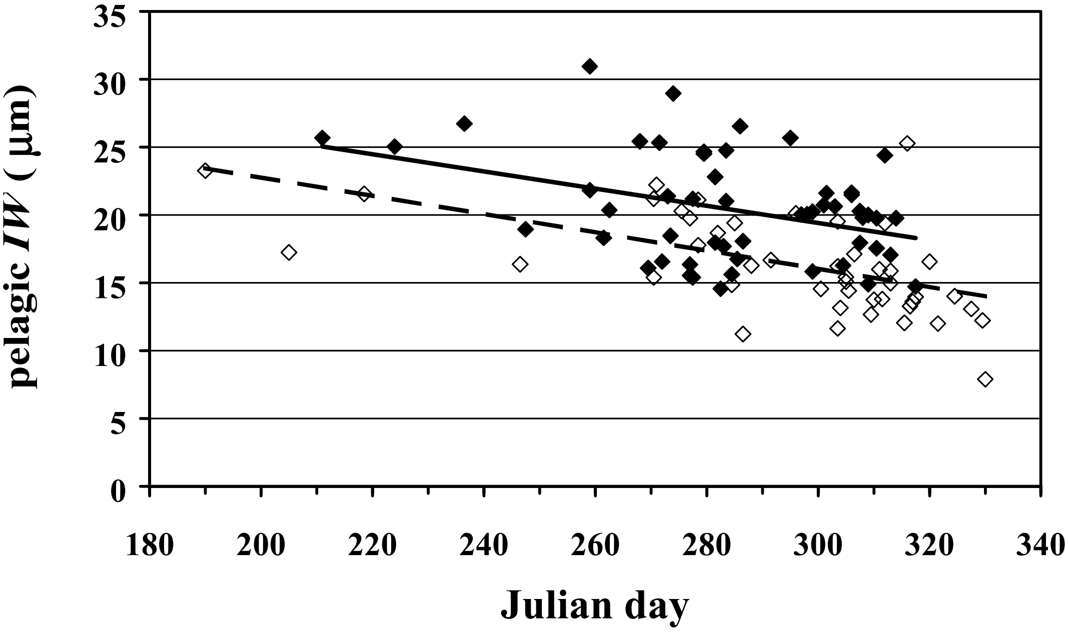
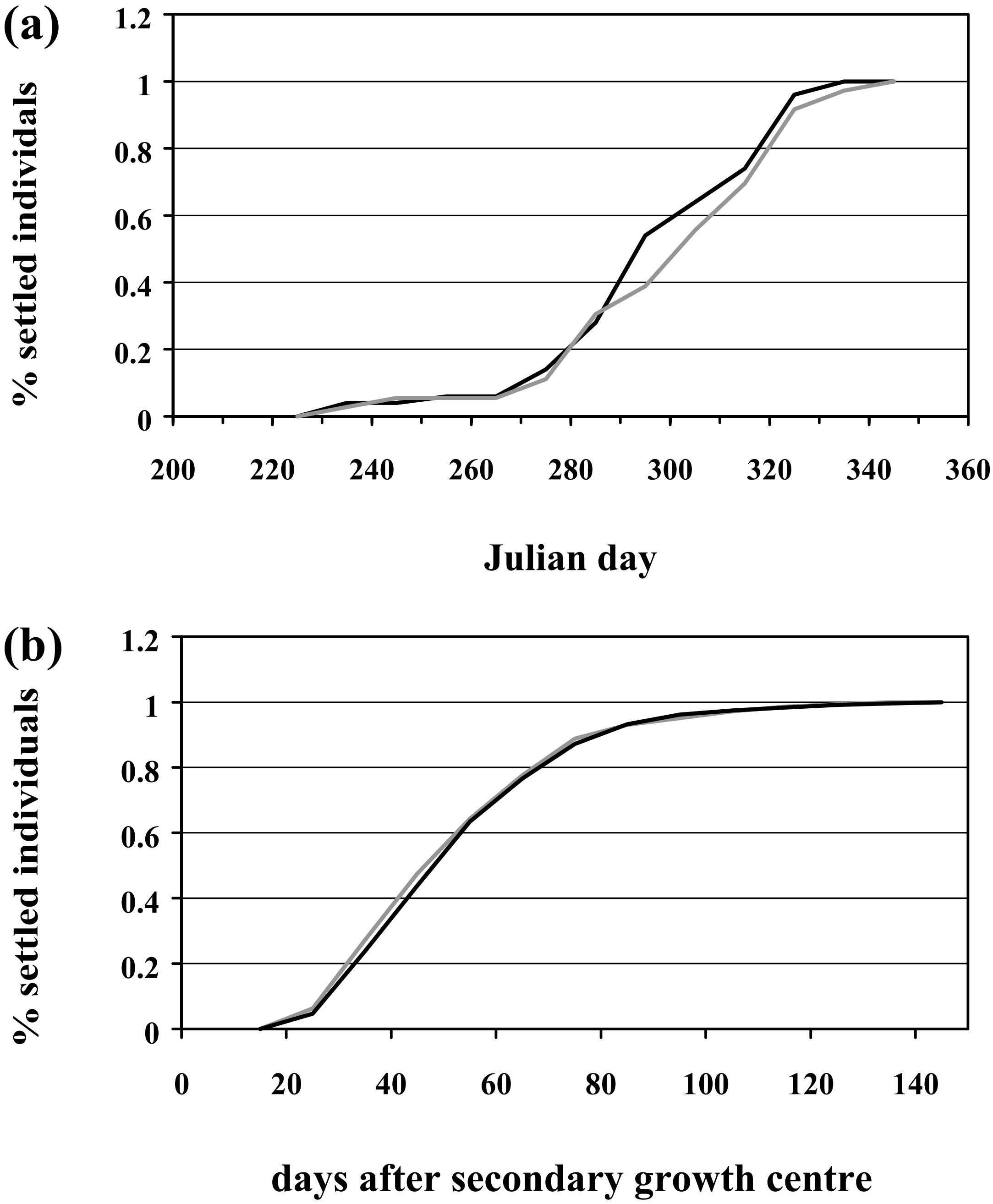


Fig. 3.1.48. Average increment widths (µm) of the pelagic stage in relation to average date of formation. Data points: ◆ : slope, ◇ : bank; Regression lines: solid line: Slope, *average IW*= 32.87-0.044·*julian day*, r^2= 0.07, p= 0.0563; broken line: Bank, *average IW* = 36.47-0.068·*julian day*, r^2= 0.24, p= 0.00064


(a)
% settled individuals
1.2
1
0.8
0.6
0.4
0.2
0
200
220
240
260
280
300
320
340
360
Julian day
(b)
% settled individuals
1.2
1
0.8
0.6
0.4
0.2
0
0
20
40
60
80
100
120
140
days after secondary growth centre

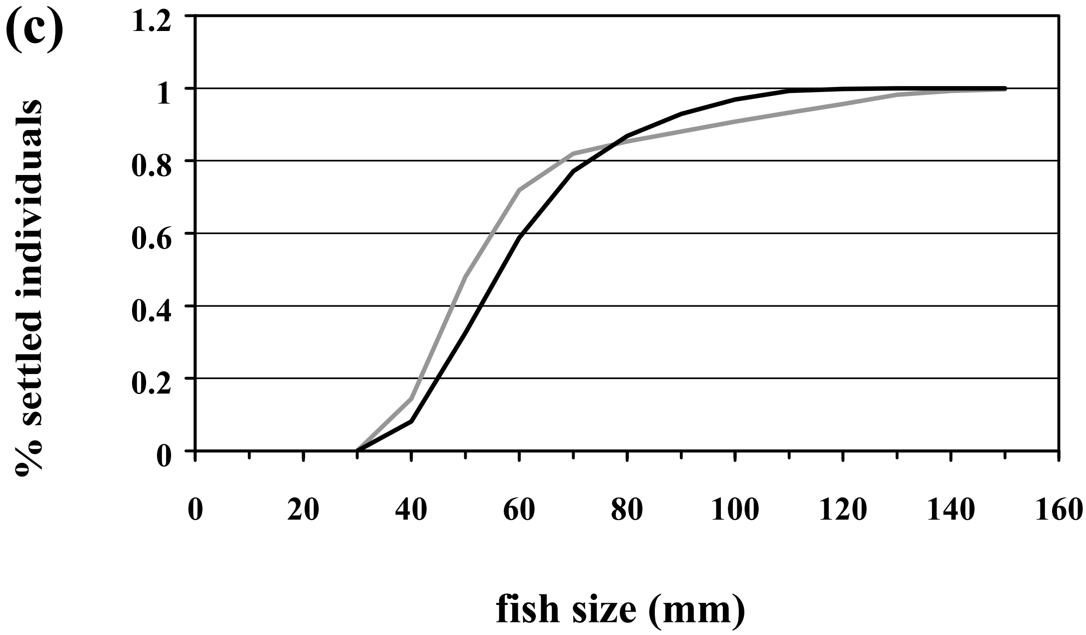


Fig. 3.1.49. Cumulative proportion of settled juvenile cod in relation to (**a**) Julian date, (**b**) days after formation of the secondary growth centre and (**c**) fish length. Black line: Slope, grey line: Bank

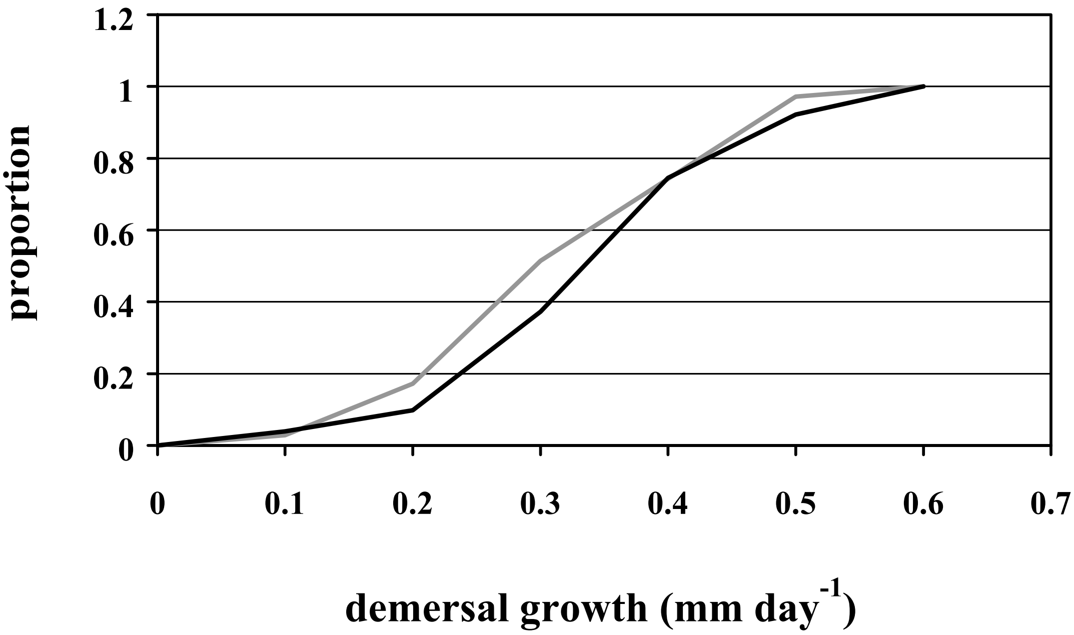


Fig. 3.1.50. Cumulative growth frequencies of juvenile Baltic cod during the demersal stage on the two localities investigated. Black line: Slope, grey line: Bank

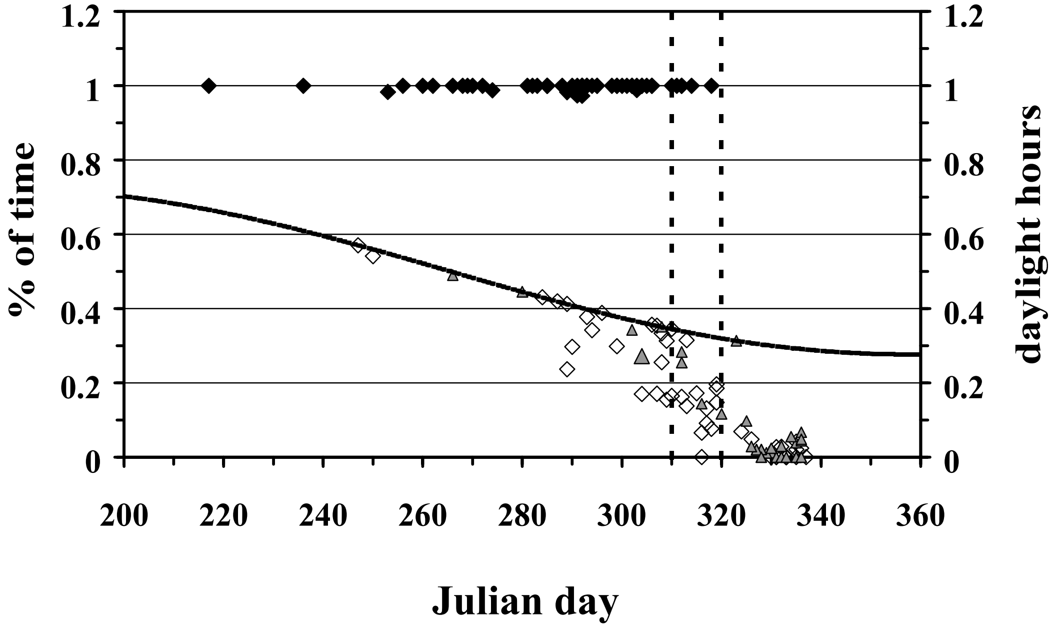


Fig. 3.1.51. The proportion of time spent above the thermocline by different life stages of juvenile Baltic cod caught on the slope locality. The bold broken line represents the proportion of hours with daylight over 24 hours (values on secondary y-axis), and thin vertical dotted lines indicate time of thermocline turnover. Data points: ◆ : I_1 (pelagic stage), ◇ : I_2 (early demersal stage, before turnover of thermocline), ▲ : I_3 and I_4 (later demersal stage, after turnover of thermocline)

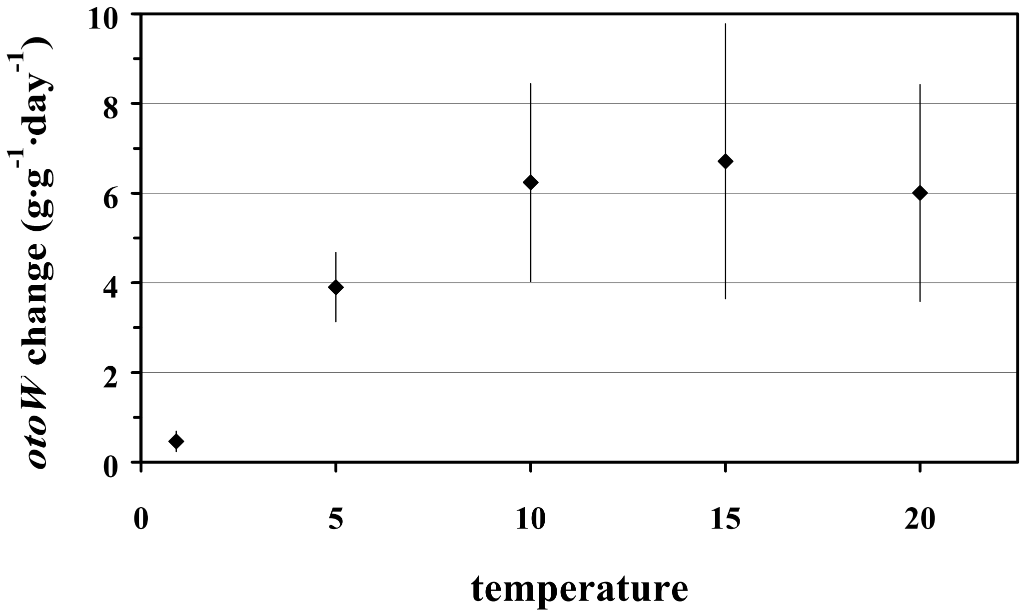


Fig- 3..52. Relationship between otolith weight change and temperature of juvenile cod reared at constant temperature (average ± SD). Otolith growth at 20 °C was measured in starving fish.

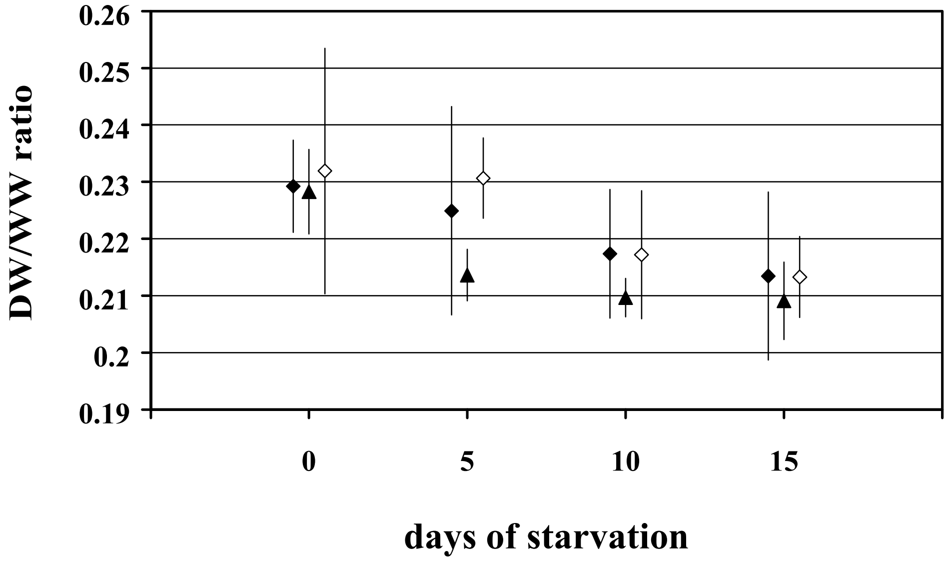


Fig. 3.1.53. Dry weight/wet weight ratio with time of starvation in juvenile cod (average ± SD). Symbols: ◆ = 5 °C, ▲ = 10 °C, ▪ = 15°C. To the values of the x-axis 0.5 was subtracted for the 5 °C group and added for the 15°C to improve the appearance of the plot.

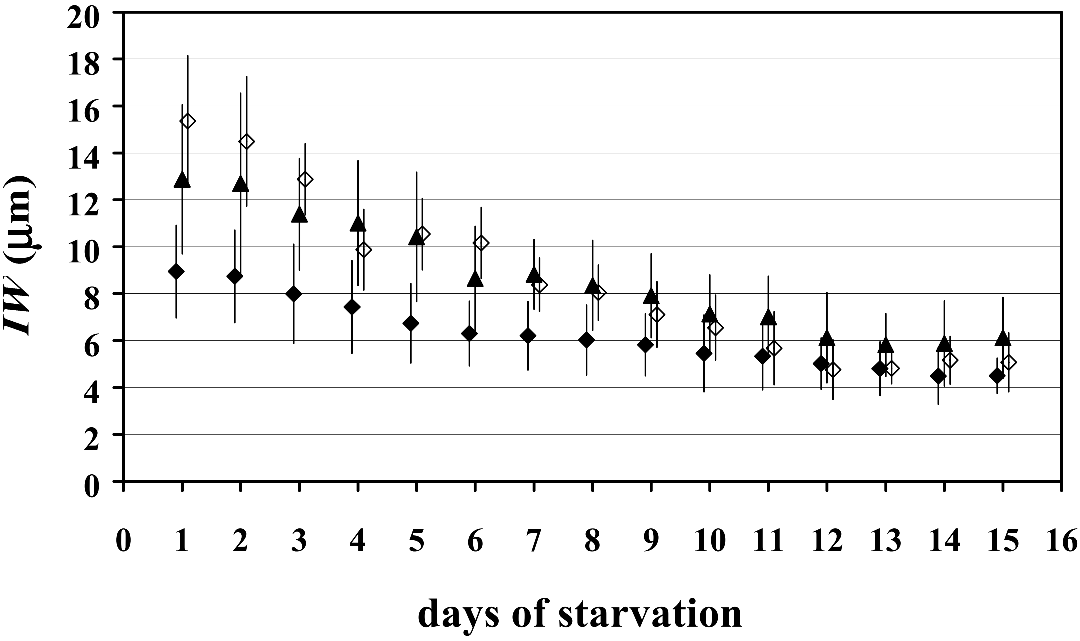


Fig. 3.1.54. Change in increment width (*IW*) with time of starvation in juvenile cod of 2-3 g wet weight (average ± SD). Symbols: ◆ = 5 °C, ▲ = 10 °C, ▪ = 15°C. To the values of the x-axis 0.1 was subtracted for the 5 °C group and added for the 15°C to improve the appearance of the plot.

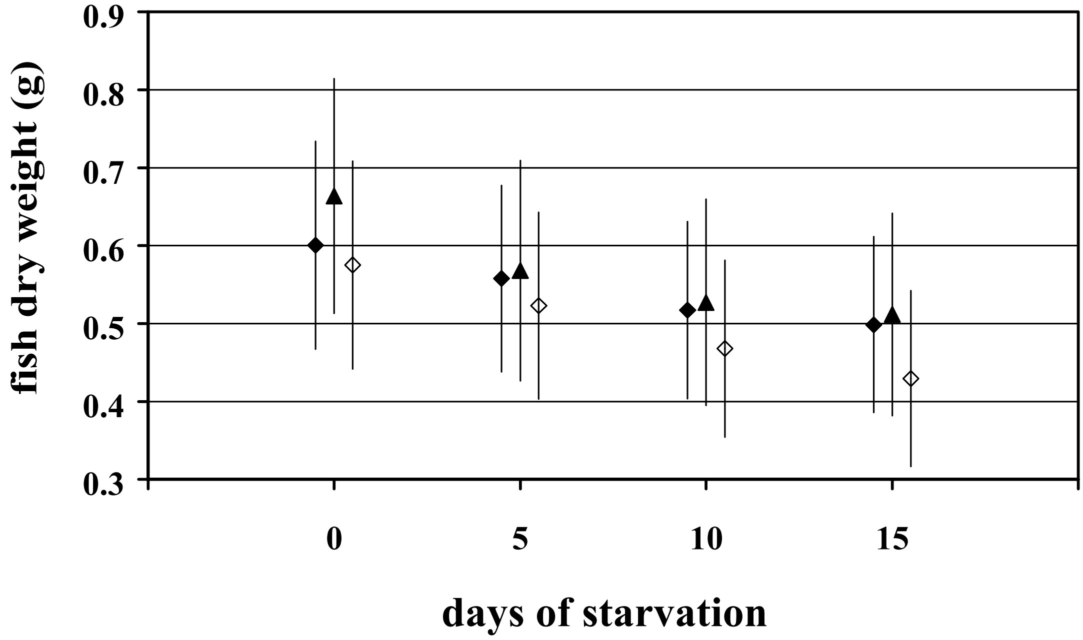


Fig. 3.1.55. Dry weight with time of starvation in juvenile cod (average ± SD). Symbols: ◆ = 5 °C, ▲ = 10 °C, ▪ = 15°C. To the values of the x-axis 0.5 was subtracted for the 5 °C group and added for the 15°C to improve the appearance of the plot.

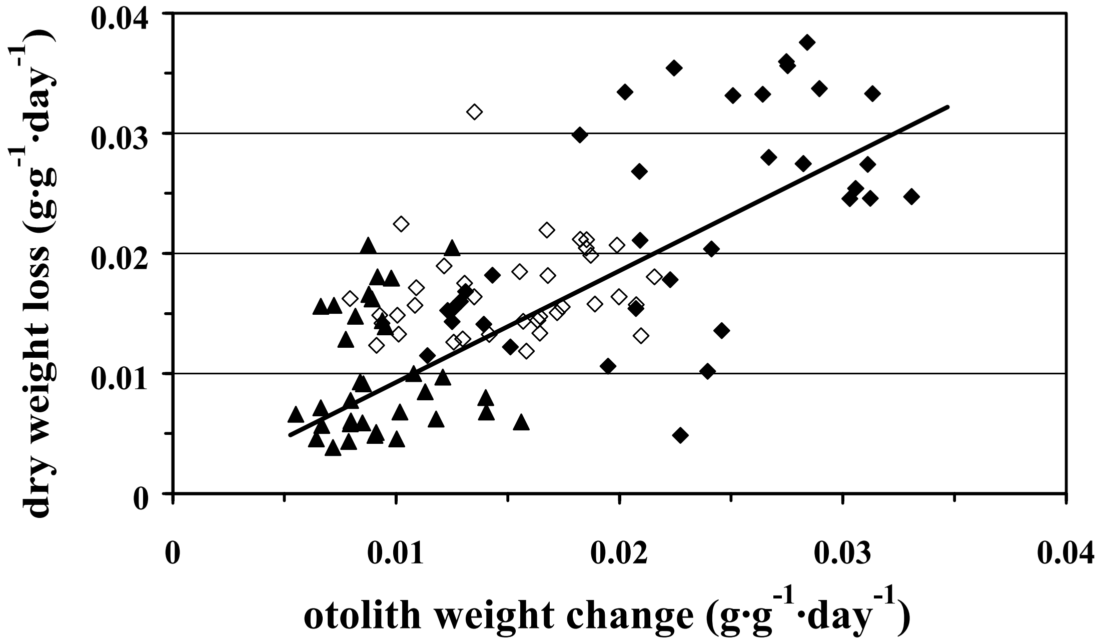


Fig. 3.1.56. Relationship between change in otolith weight and fish dry weight due to starvation. dry weight loss (g g^{-1} d^{-1}) = 1.016·otolith weight change (g g^{-1} d^{-1}), r^2= 0.39. Data points: ◆ = 0-5 days, ▪ = 5-10 days, ▲ = 10-15 days of starvation.

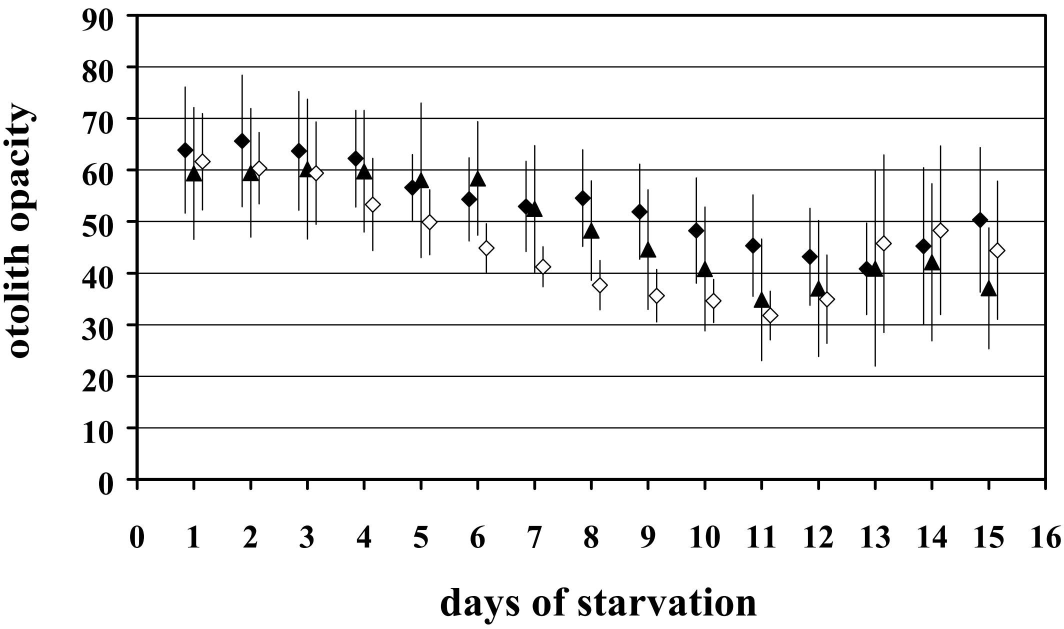


Fig. 3.1.57. Otolith opacity with time of starvation in juvenile cod (average ± SD). Symbols: ◆ = 5 °C, ▲ = 10 °C, ▪ = 15°C. To the values of the x-axis 0.1 was subtracted for the 5 °C group and added for the 15°C to improve the appearance of the plot.

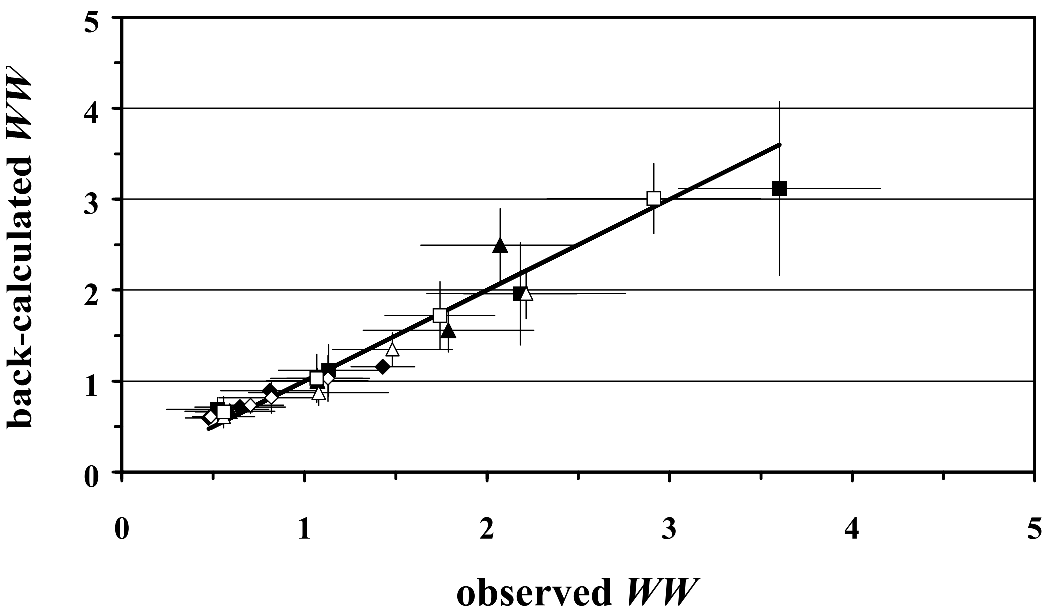


Fig. 3.1.58. Comparison of average back-calculated and observed wet weights (g) from the growth experiment (average ± SD). Back-calculated wet weight= 0.952·observed wet weight (n= 24, r^2= 0.95). Data points: Closed symbols= maximum ration, open symbols= low ration, ◆ = 5 °C, ▲ = 10 °C, ▪ = 15°C. The line indicates the 1:1 expected relationship.

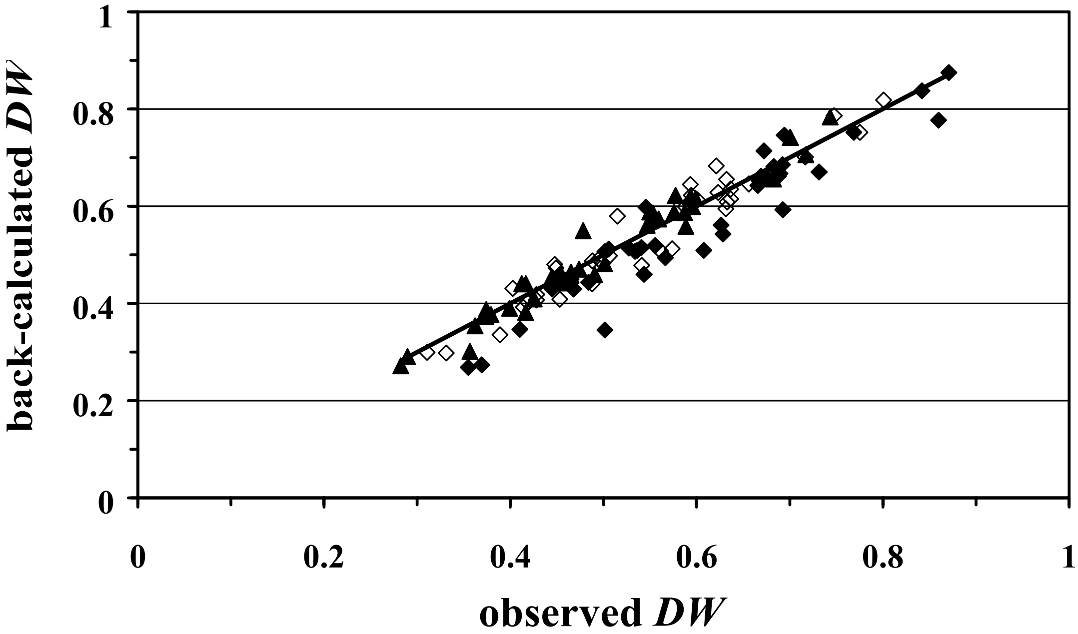


Fig. 3.1.59. Comparison of observed dry weights from the starvation experiment with back-calculated model outputs in (g). Back-calculated dry weight= 1.01·observed dry weight (n= 150, r^2= 0.92). Symbols: ◆ = day 0, ▪ = day 5, ▲ = day 10 of the starvation experiment. The line indicates the 1:1 expected relationship.

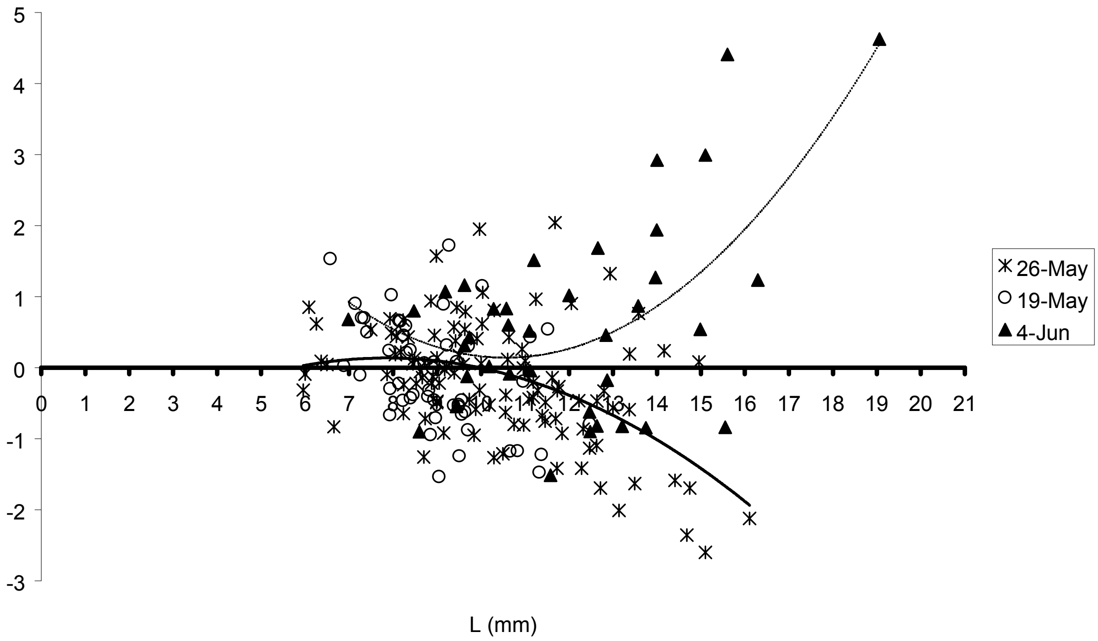


Fig. 3.1.60. Residual analysis of the relationship between length of the larvae and estimated otolith radius (are/pi)$^{0.5}$. Polynomial curves of second degree were fitted to the data from the 26th of May (r^2=0.3576) and the 4th of June (r^2=0.241).

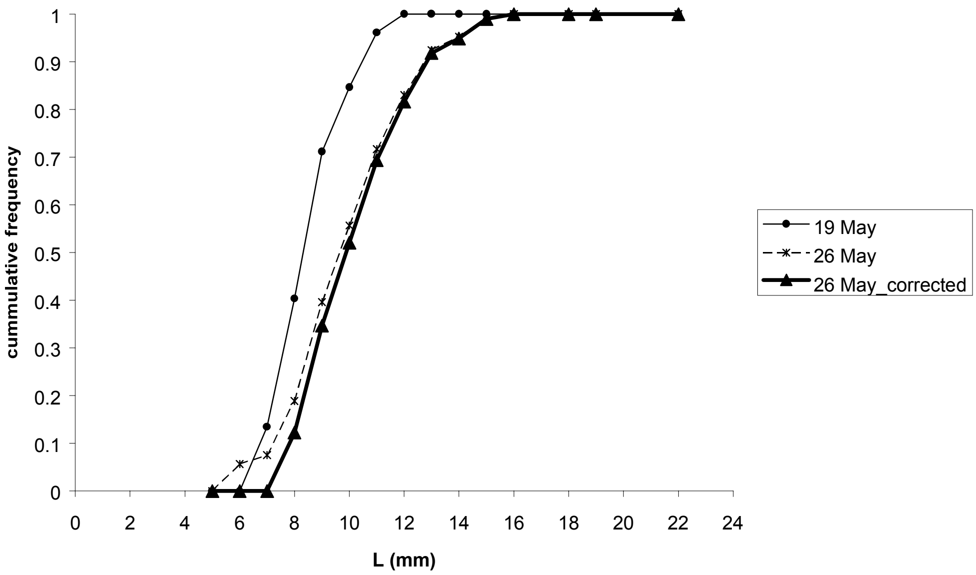


Fig. 3.1.61. Cumulative frequency distribution of larvae from different length groups caught on the 19th and the 26th of May. The figure also shows the resulting curve after correcting for recruitment on the 26th of May.

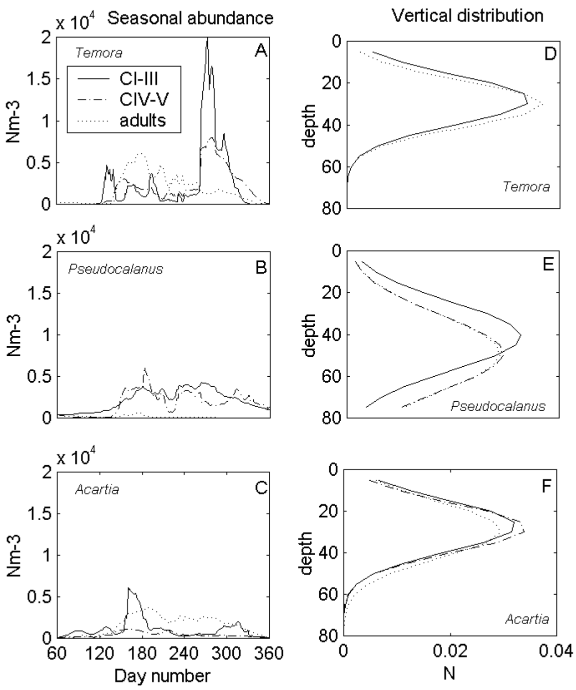


Fig. 3.1.62 a-c. Seasonal trends in the abundance (Nm^{-3}) of the different ontogenetic stages (CI-III, CIV-V,adults) of *Temora*, *Acartia* and *Pseudocalanus* in the Baltic Sea as estimated from the GAM model. d-f. Patterns in their vertical distribution. The OX-axis shows numbers estimated from a normal distribution with total number of individuals=1.

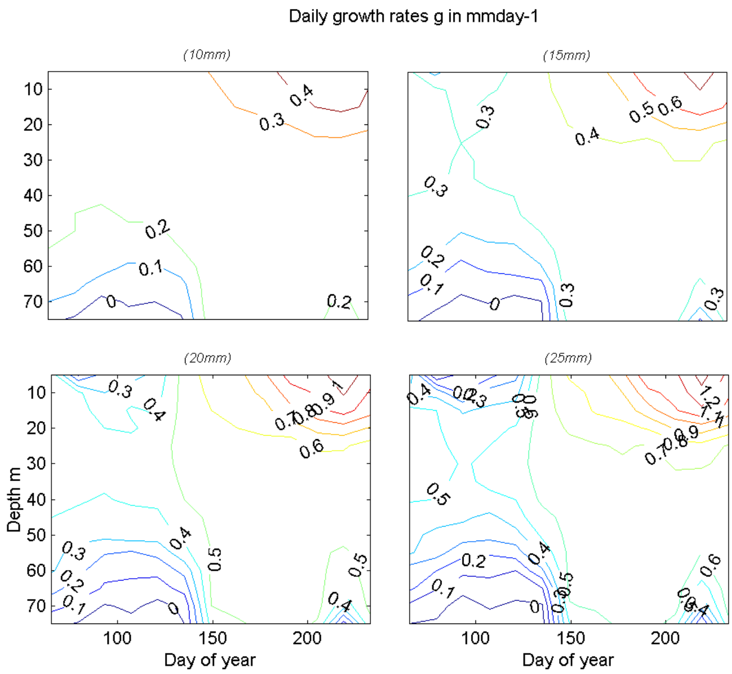


Fig. 3.1.63. Predicted maximum growth rates (mmday^{-1}) at depth for sprat larvae 10-25 mm long over the spawning season in the Baltic Sea

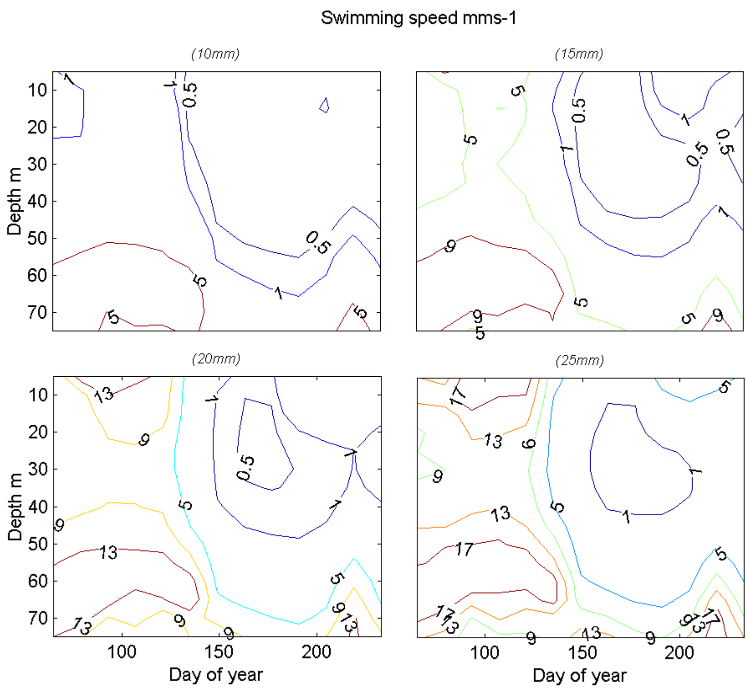


Fig 3.1.64. Predicted swimming speeds (mmday^{-1}) at depth for sprat larvae 10-25 mm long over the spawning season in the Baltic Sea

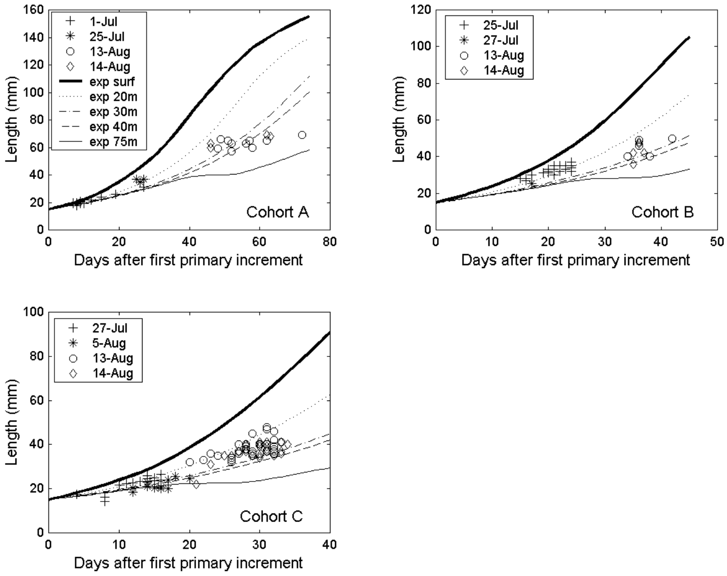


Fig. 3.1.65. Predicted (lines) and observed (points) length-at-age for three different sprat cohorts. Predictions showed length-at-age in larvae maximizing growth rates over the water column and larvae living at 20, 30, 40 and 75 m respectively. Observed length-at-age are calculated from larvae of the same cohort caught at different sampling dates.
Note that scales are different according the age of the larvae of each cohort caught in the samples

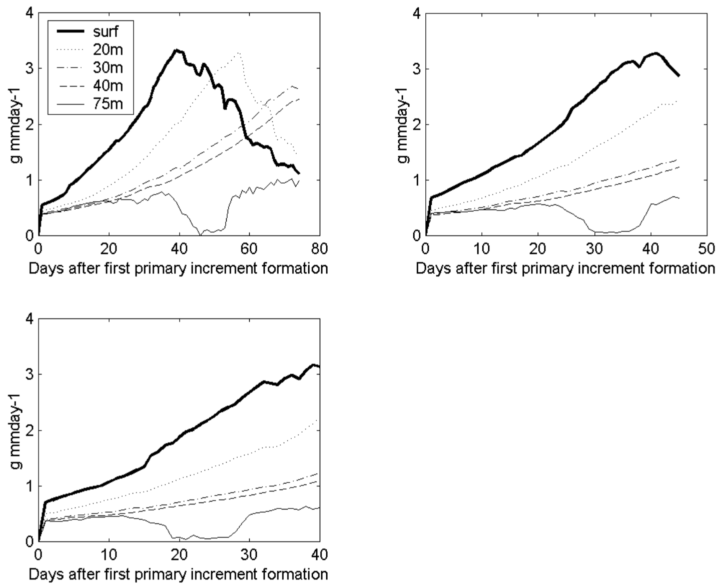


Fig. 3.1.66. Growth rates (mmday^{-1}) as predicted from the model for the three different cohorts when individuals maximize growth rates over the water column and larvae living at 20, 30, 40 and 75 m respectively.

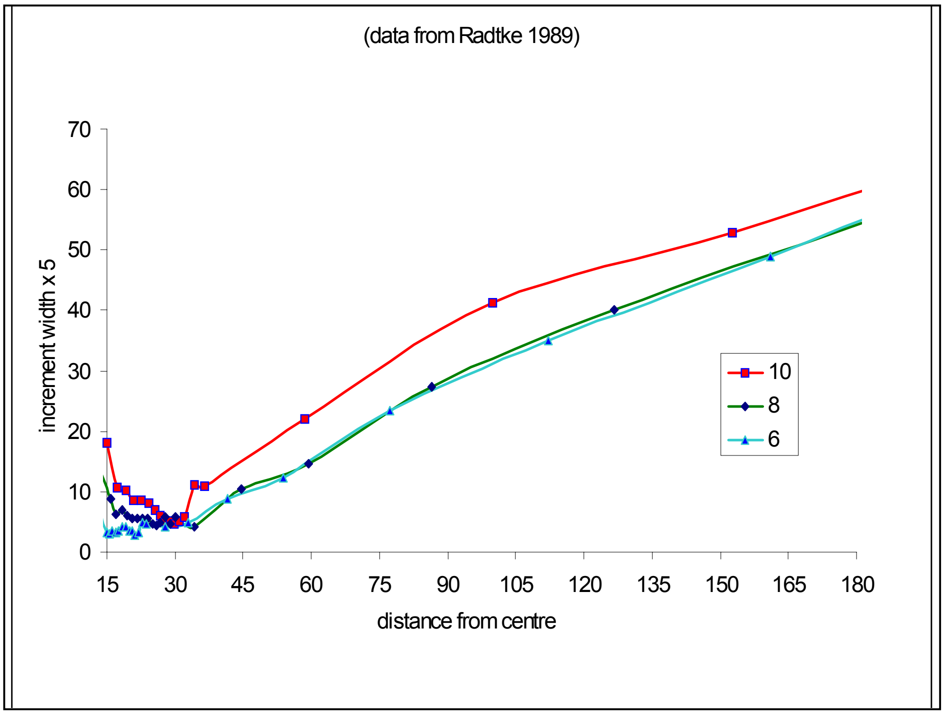


Fig. 3.1.67. Larval and juvenile otolith growth trajectories, from experimental conditions at three different temperatures (6, 8, and 10 centigrade, data from Radtke 1989).

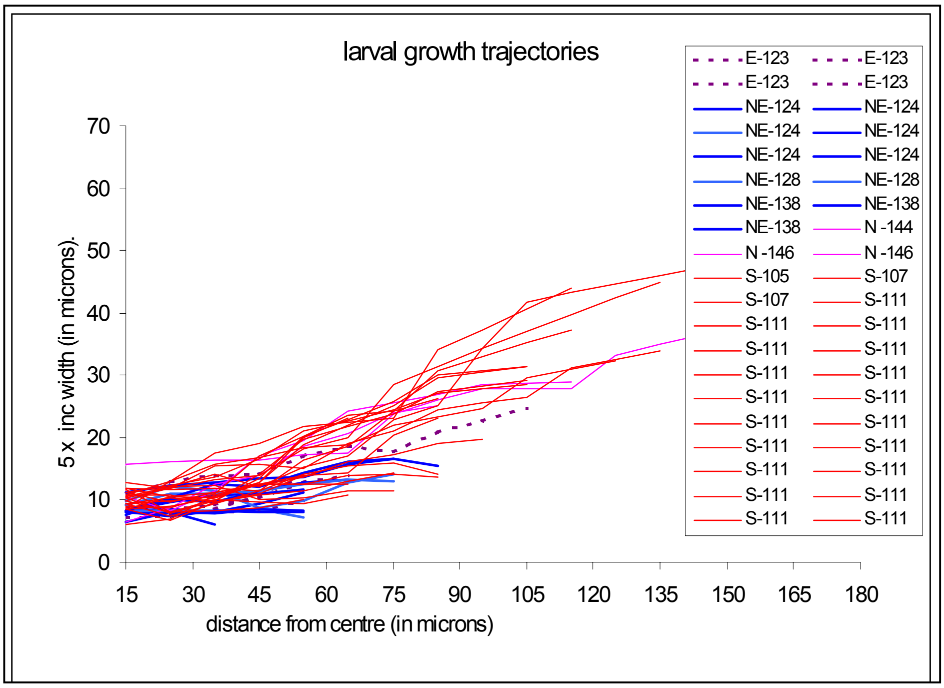


Fig. 3.1.68. Larval otolith growth trajectories, from individual juveniles caught at different positions in the Bornholm Basin.

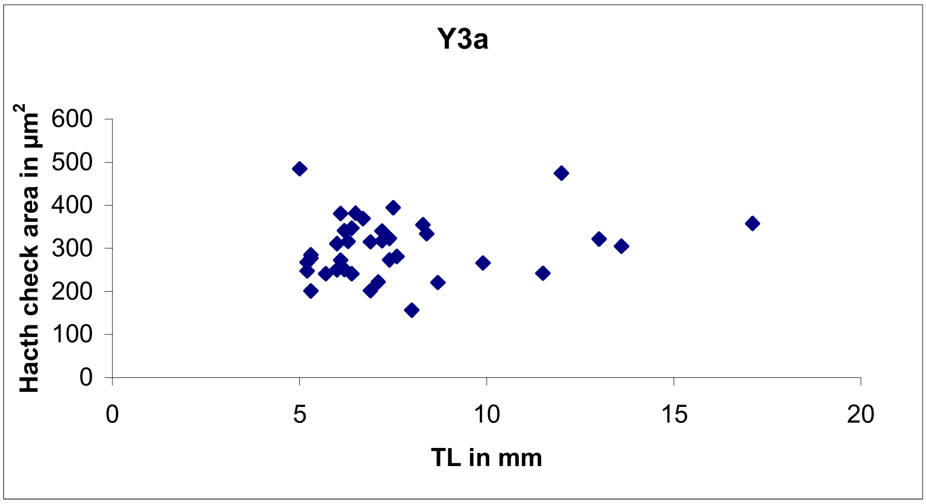


Fig. 3.1.69. Fish length plotted against hatch check area.

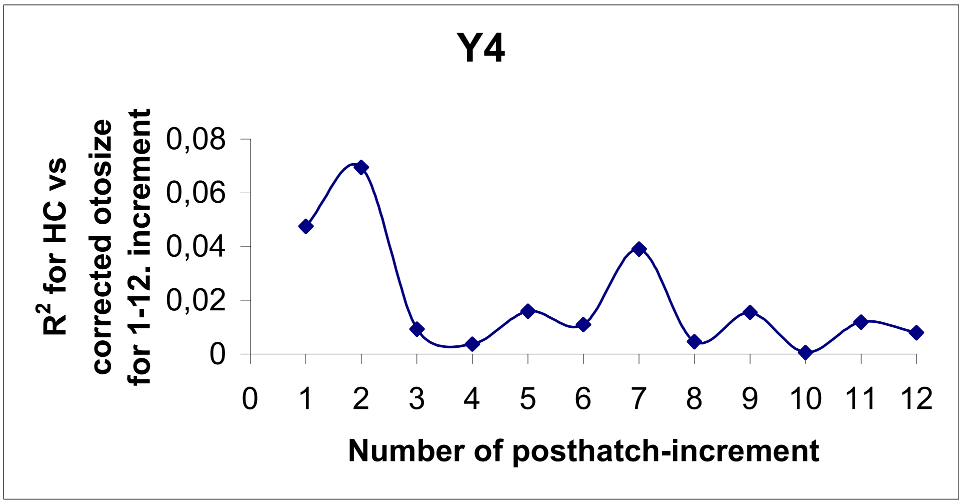


Fig. 3.1.70. R^2 for the correlation between hatchcheck and the each of the 12 first formed post hatched increments. The tested increments were corrected for hatchcheck size prior to regression analysis.

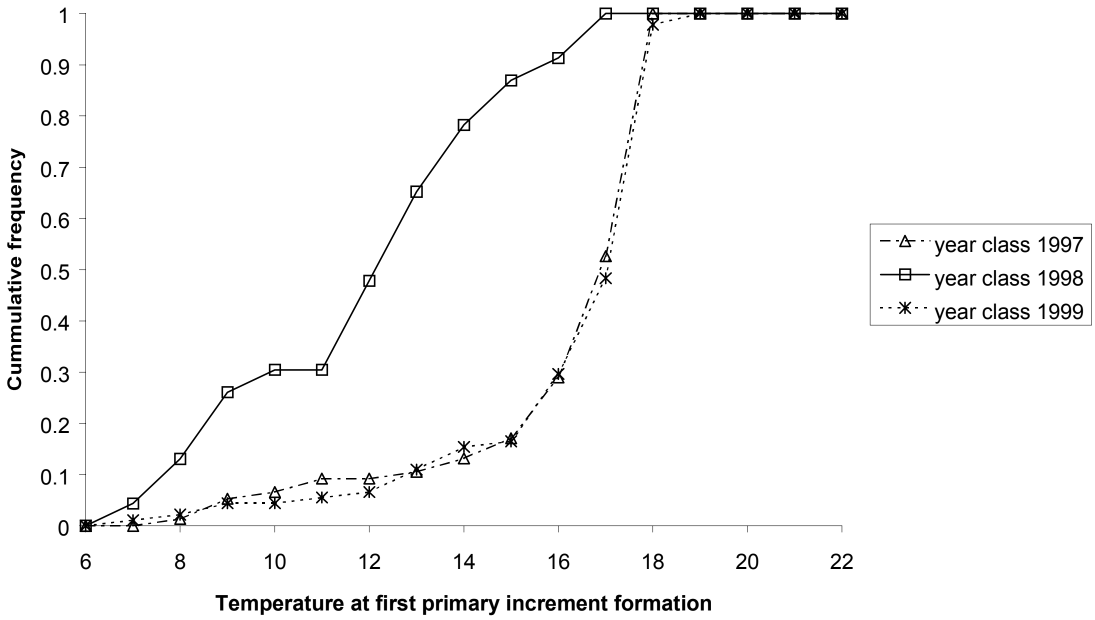


Fig. 3.1.71. Temperature at first primary increment formation estimated for age 1 sprat from three different year classes

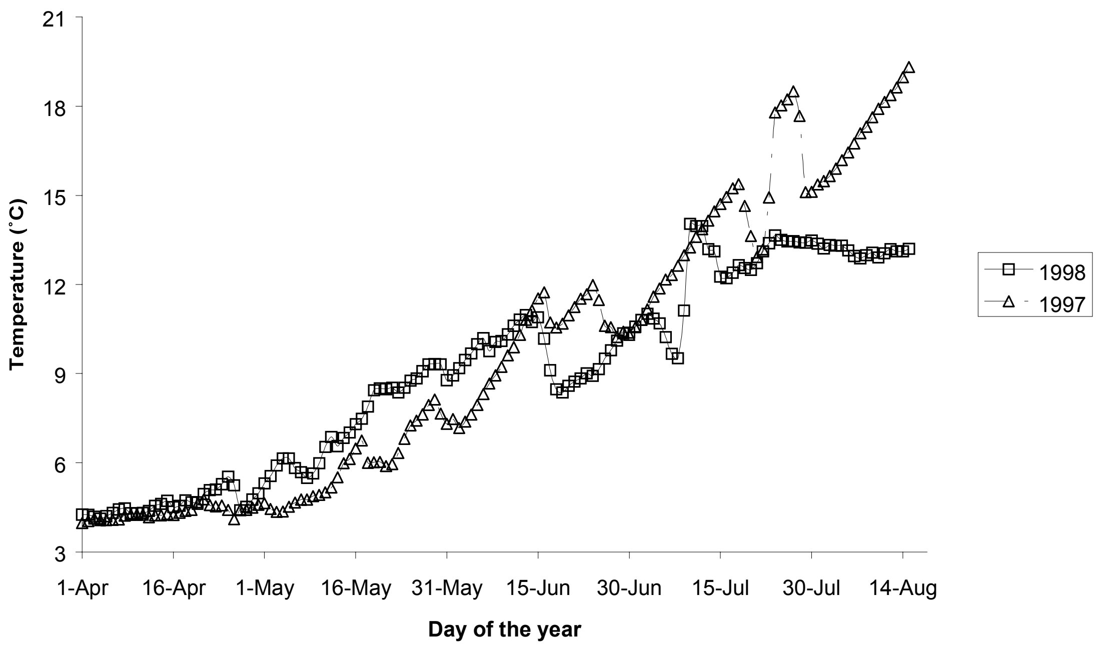


Fig. 3.1.72. Average temperature (˚C) over the first 10 m depth measured over the sprat-spawning season in 1997-1998 used to estimate date of first primary increment formation in survivors from the 97 and 98 year-class respectively.

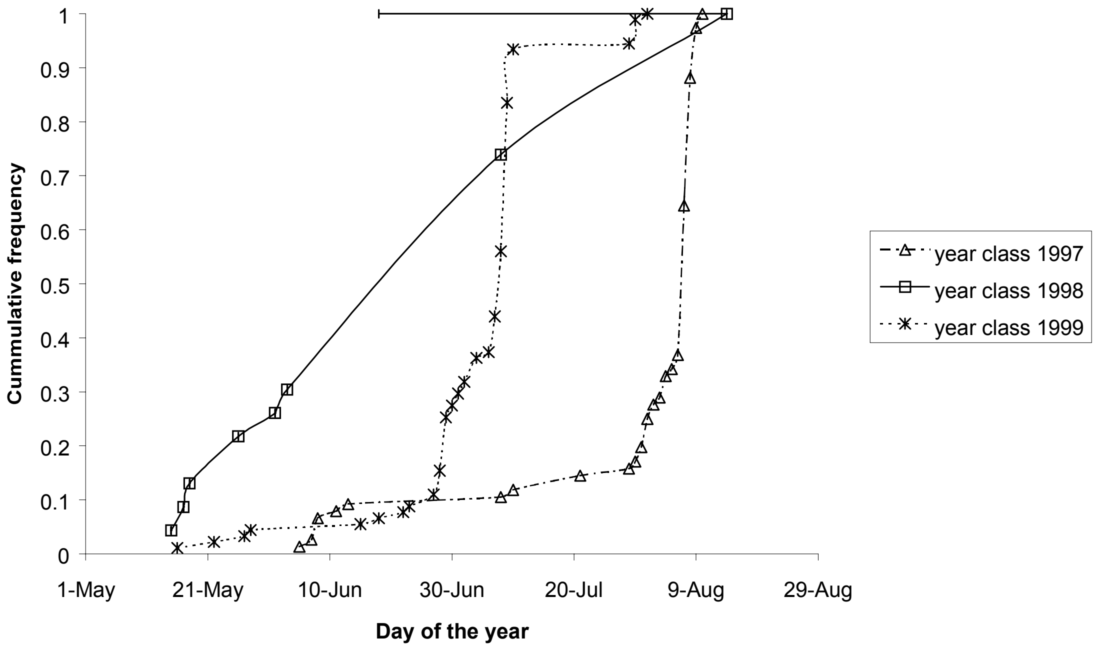


Fig. 3.1.73. Day at first primary increment formation estimated for age 1 sprat from three different year classes. The horizontal error bar shown for the 98 year class shows the range of days that could correspond to the higher predicted temperatures showing the difficulty in estimating day of first primary increment formation from estimated temperatures when temperatures are very similar over time.

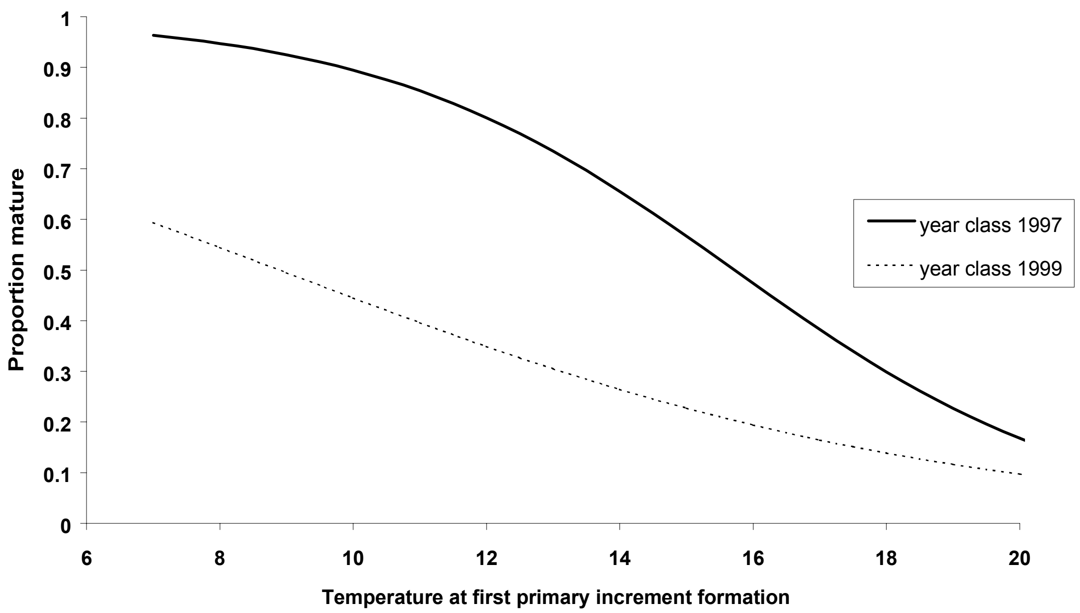


Fig. 3.1.74. Proportion mature at age 1 calculated for the year class 1997 and 1999 as a function of temperature at first primary increment formation.

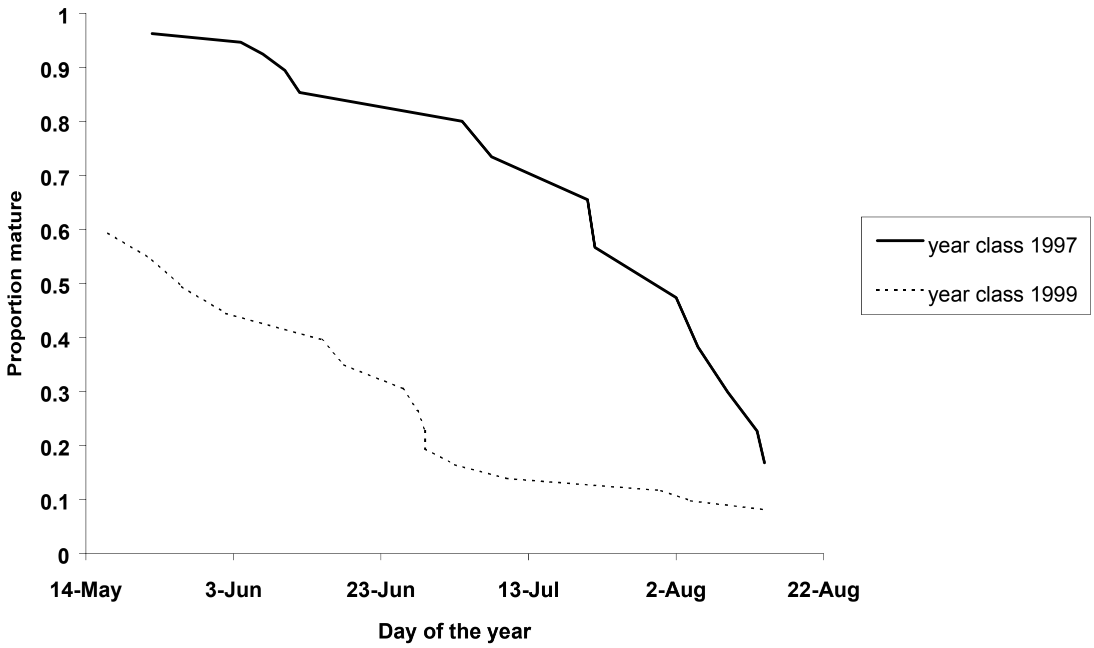


Fig. 3.1.75. Proportion mature at age 1 calculated for the year class 1997 and 1999 as a function of date of first primary increment formation.

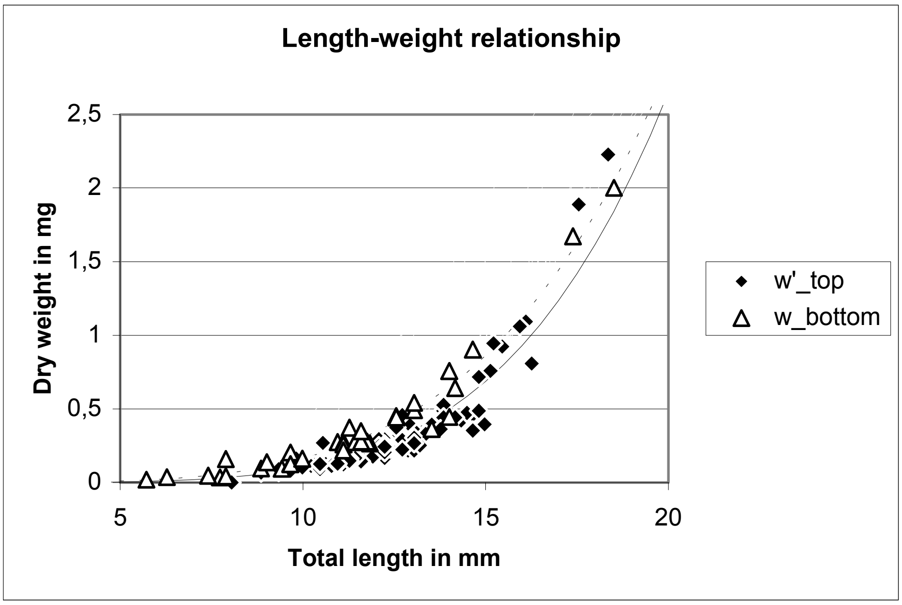


Fig 3.1.76. Length-weight relationship of sprat larvae from top and bottom layers. Broken line: Nonlinear regression of the length-weight relationship for larvae caught in 40-70 m. Solid line: Nonlinear regression of the length-weight relationship for larvae caught in 0-20 m.

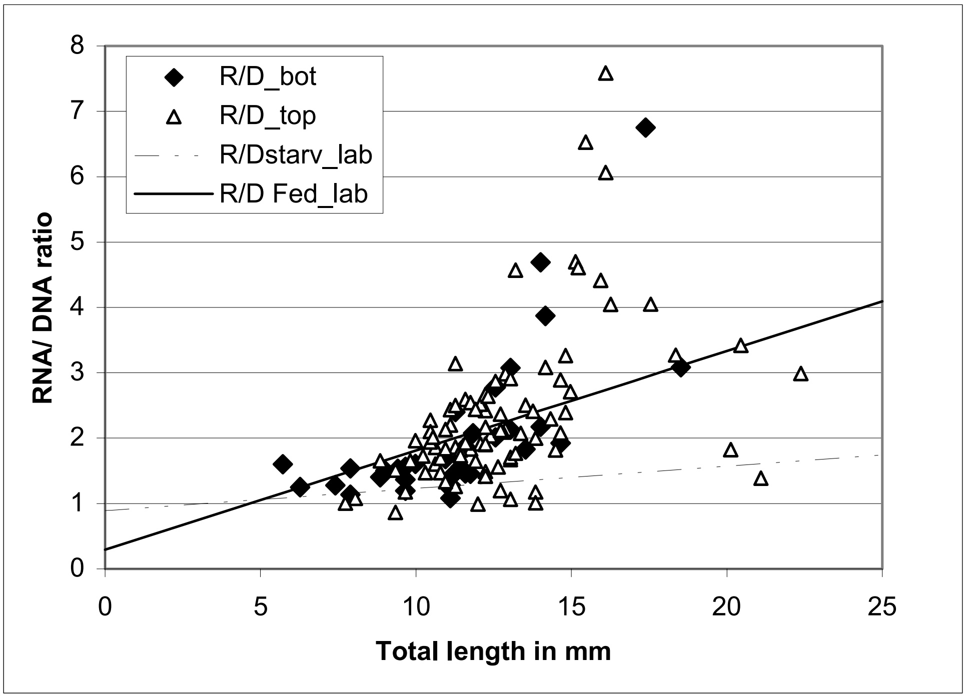


Fig. 3.1.77. Relationship between RNA/DNA ratios and larval total length of Baltic sprat (Sprattus sprattus L.). R/D_bot: RNA/DNA ratio of larvae obtained from bottom layers (40-70 m), R/D_top: RNA/DNA ratio of larvae obtained from top layers (0-20 m), R/D starv_lab: RNA/DNA ratio of laboratory reared herring larvae deprived of food for 6-9-days, R/D fed_lab: RNA/DNA ratio of laboratory reared herring larvae that have been regularly fed.

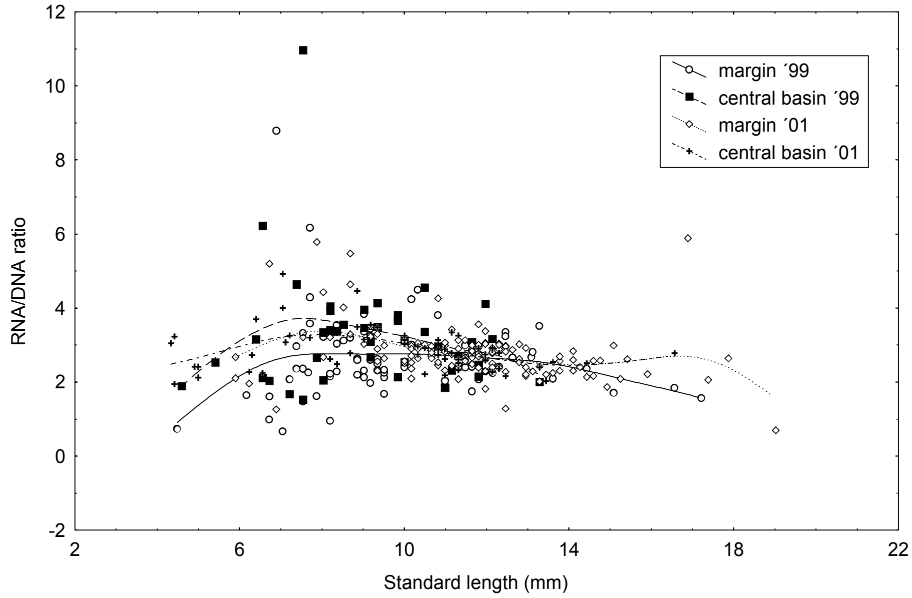


Fig. 3.1.78. Relationship between RNA/DNA ratios and larval standard length of Baltic sprat (Sprattus sprattus L.) caught in May/June 1999 and May/June 2001 Lines are least-square fittings.

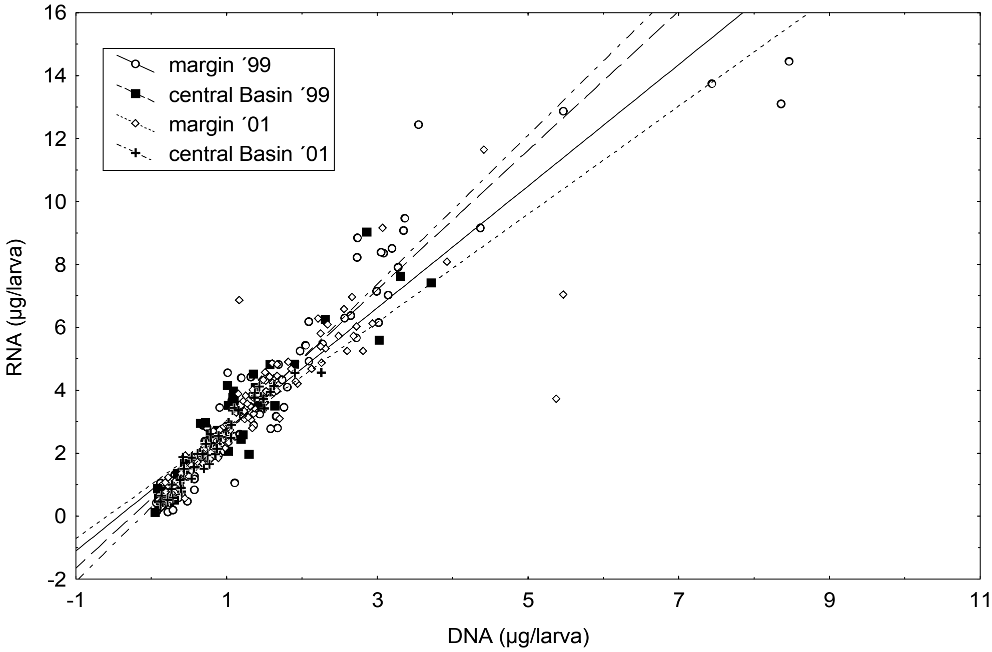


Fig. 3.1.79. Relationship between RNA and DNA of Baltic sprat (Sprattus sprattus L.) caught in May/June 1999and May/June 2001.

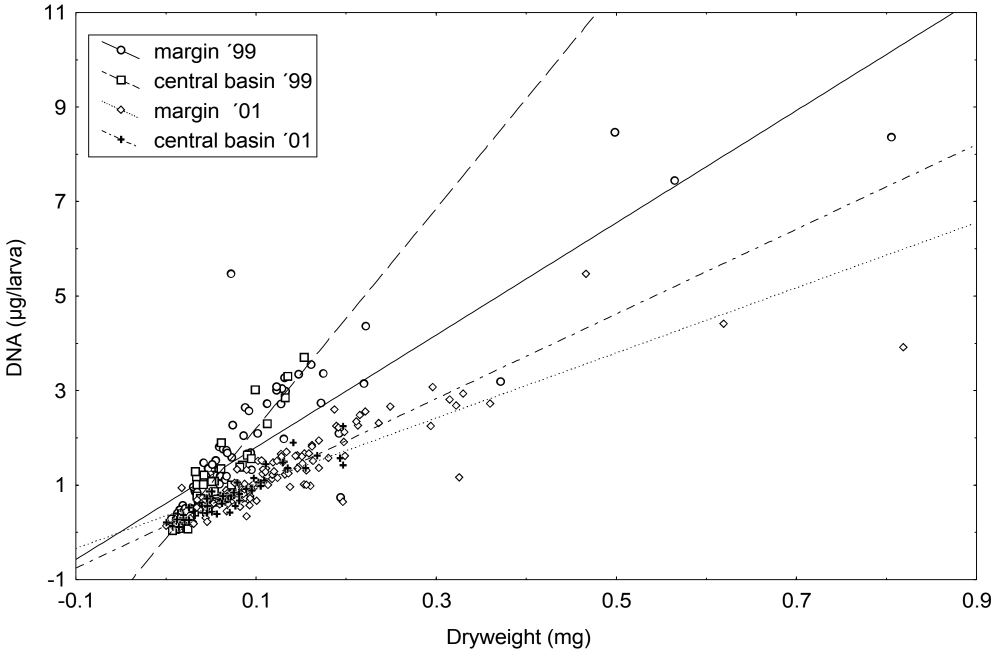


Fig. 3.1.80. Relationship between DNA-content and larval dry weight of Baltic sprat (Sprattus sprattus L.) caught in May/June 1999 and May/June 2001.

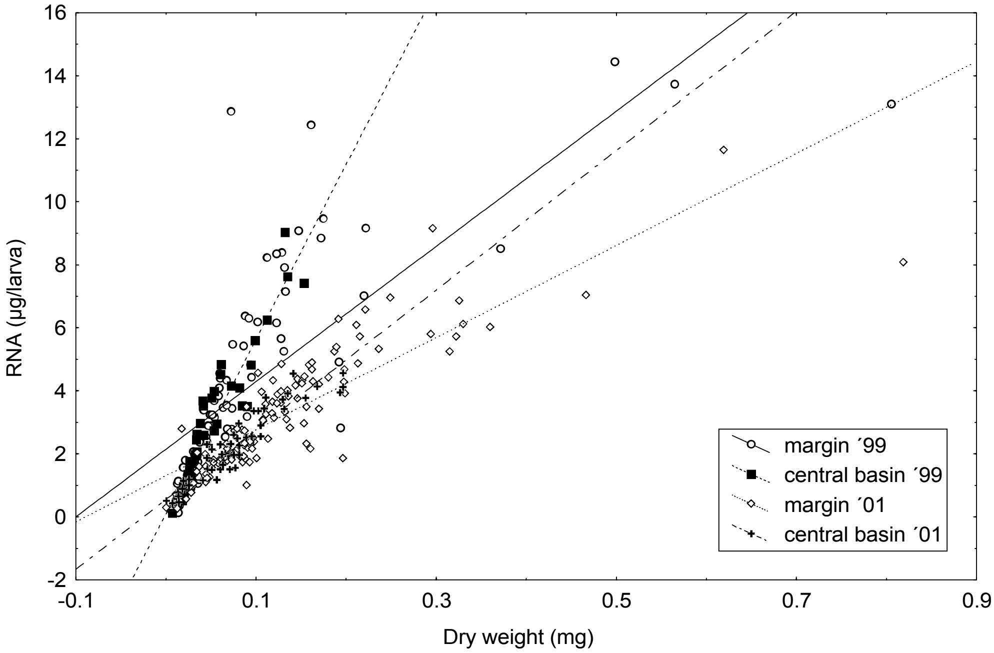


Fig. 3.1.81. Relationship between DNA and larval dry weight of Baltic sprat (Sprattus sprattus L.) caught in May/June 1999and May/June 2001.

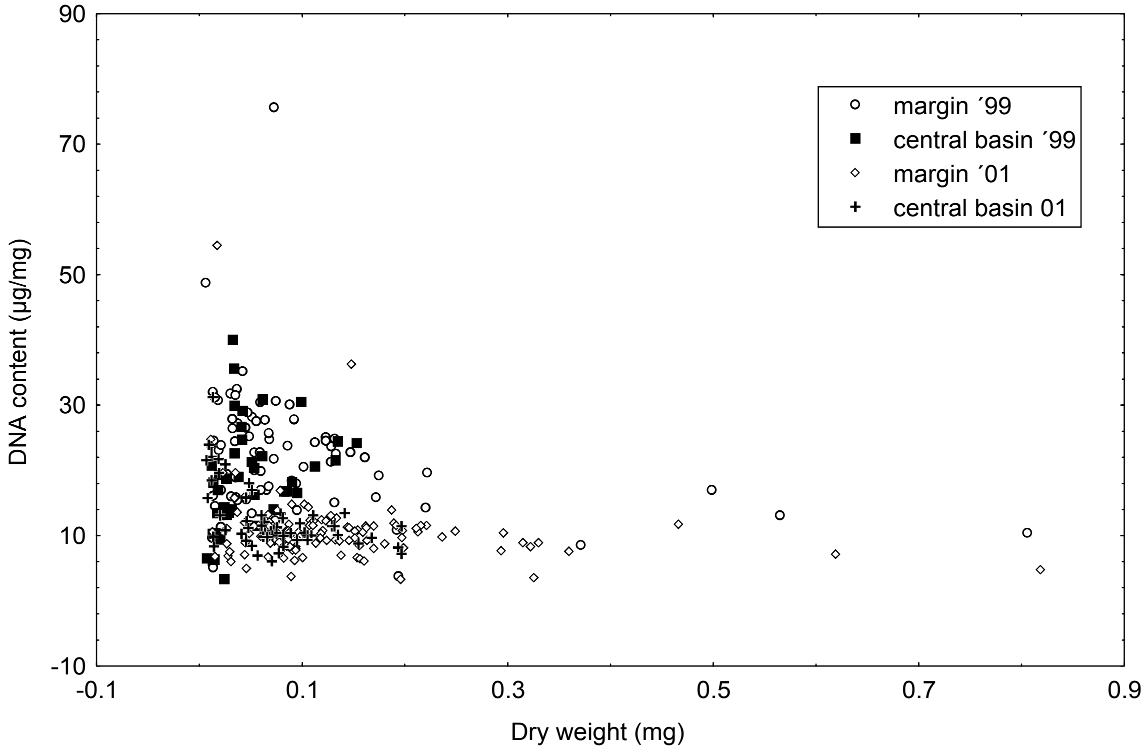


Fig. 3.1.82. Relationship between DNA-content (normalized to µg DNA/mg Larva) and larval dry weight of Baltic sprat (Sprattus sprattus L.) caught in May/June 1999and May/June 2001.

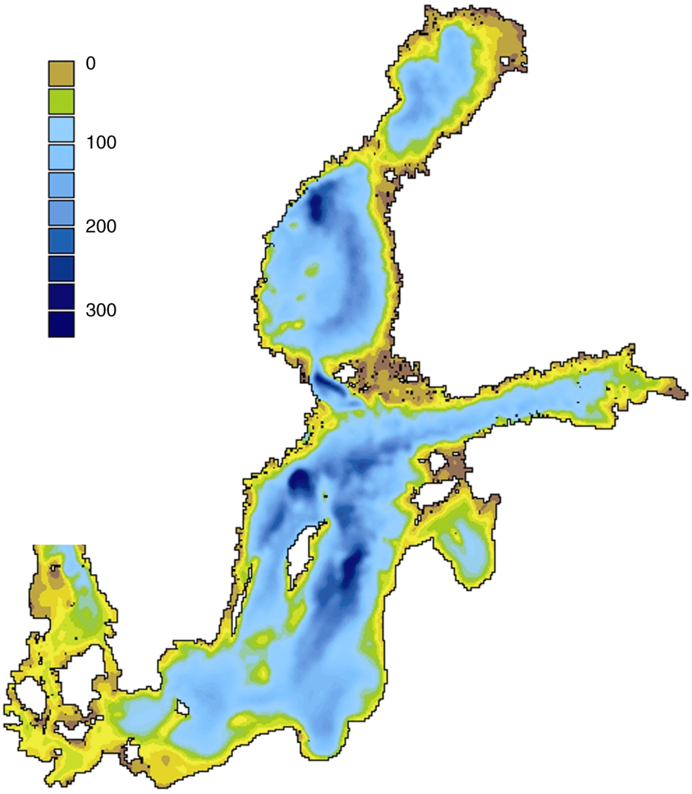


Fig 3.2.1. Bottom topography of the Baltic Sea (from Seifert and Keyser, 1995).

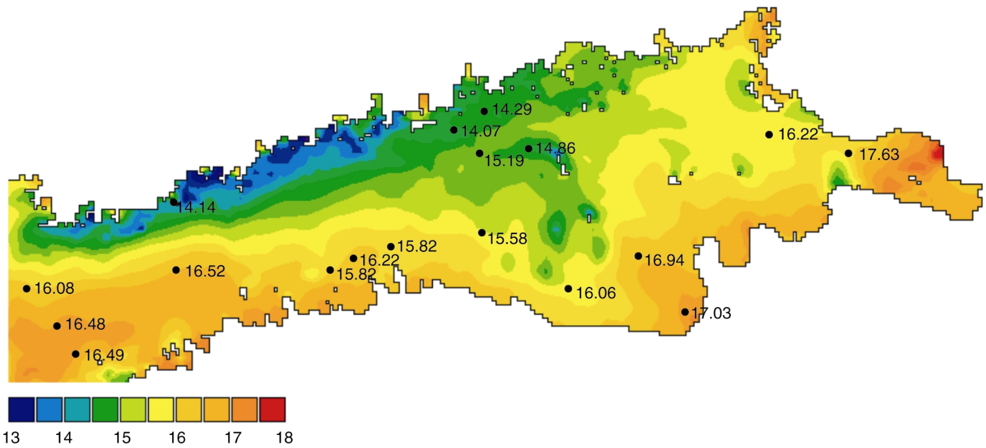


Fig. 3.2.2. Simulated surface layer temperature between 0 and 2.5 m on August 21, 1992. Temperature observations are marked with black dot and the corresponding value.

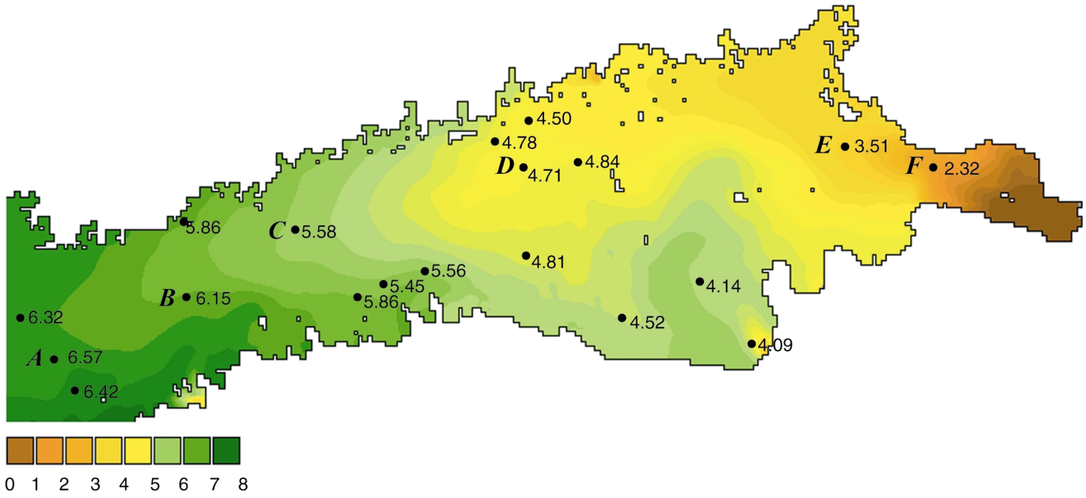


Fig. 3.2.3. Simulated surface layer salinity between 0 and 2.5 m on August 21, 1992. Salinity observations are marked with black dot and the corresponding value.

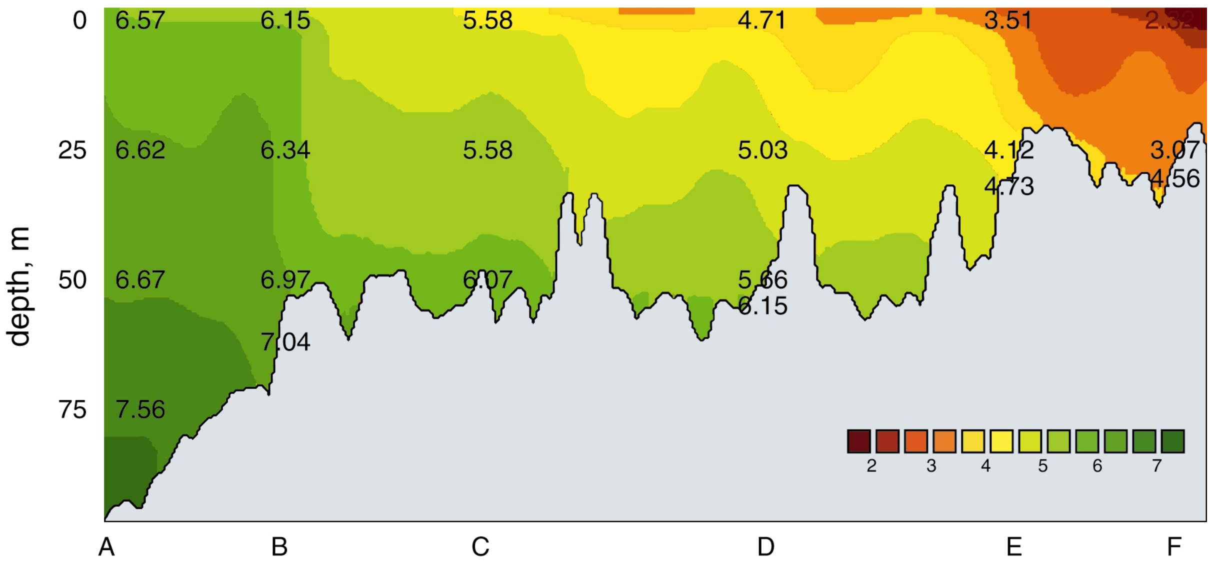


Fig. 3.2.4. The simulated west-east salinity-section in the Gulf of Finland on August 21, 1992. The location of the section is shown by letters from A to F in Fig. 3.2.3. The scale of the corresponding colours is shown below.

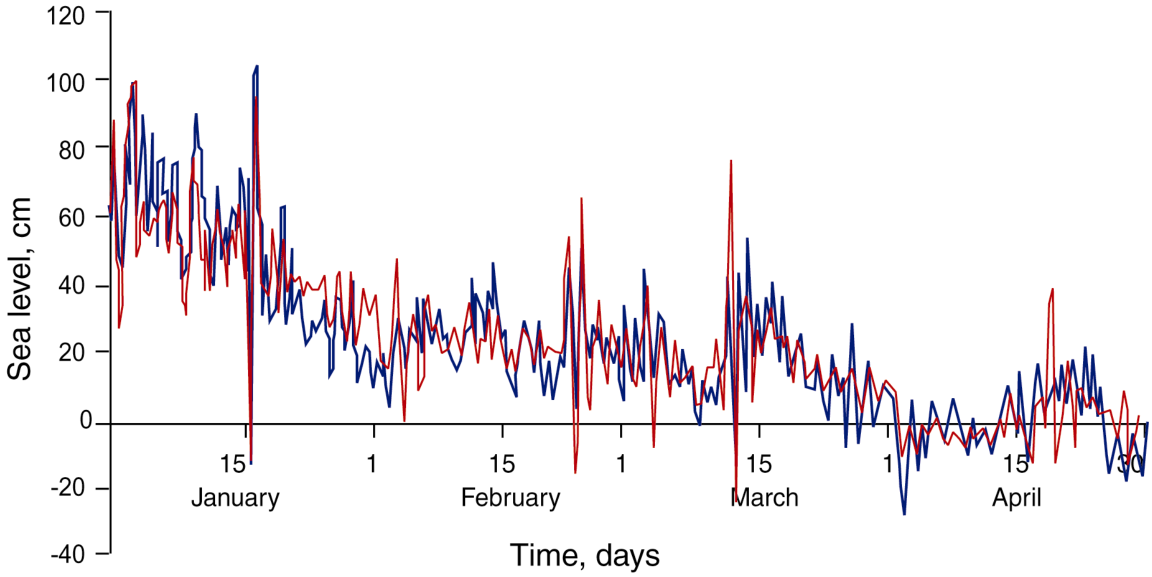


Fig. 3.2.5. Time-evolution (in hours) of the sea-level height (in cm) at the station Helsinki during January 1-April 30, 1992. The observed sea-levels are marked with a dark line, the model results with a light line.

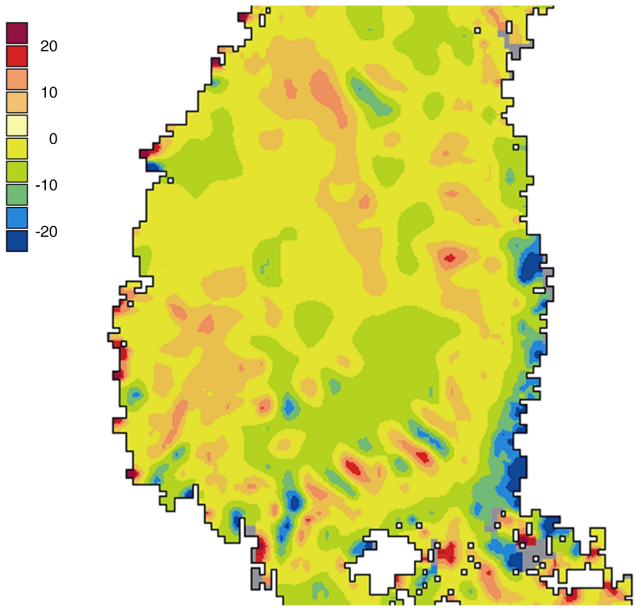


Fig. 3.2.6. Upwelling/downwelling index in percentage in the Bothnian Sea (upwelling – positive values, downwelling –negative values). The corresponding scale of the colours is shown in the palette.

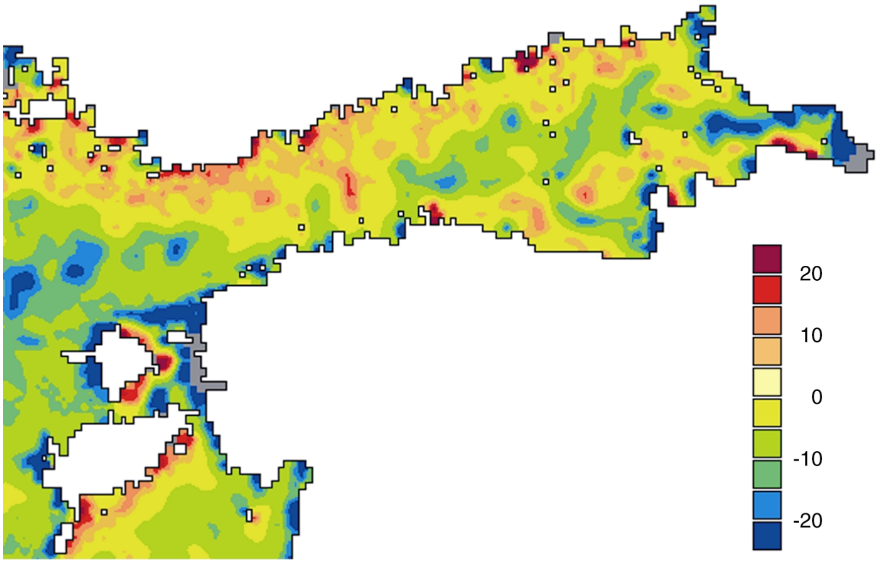


Fig. 3.2.7. Upwelling/downwelling index in percentage in the Gulf of Finland and around the islands of Hiiumaa and Saaremaa.

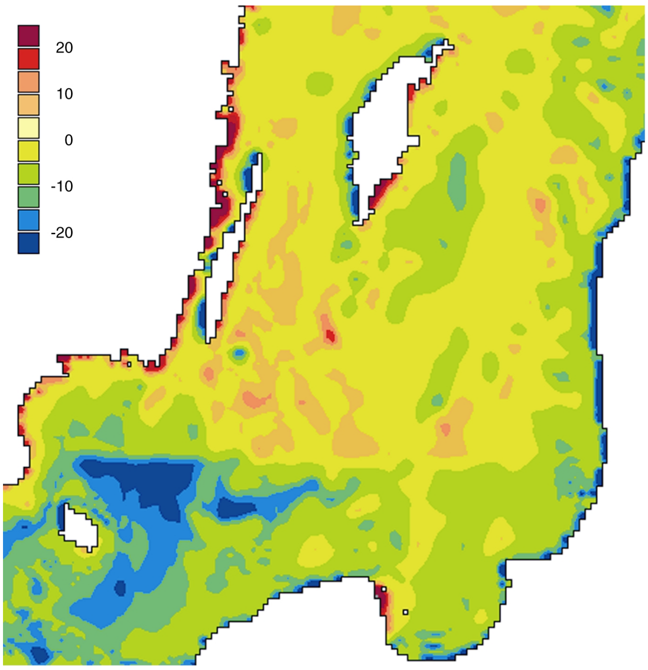


Fig. 3.2.8 Upwelling/downwelling index in percentage in the Baltic Proper.

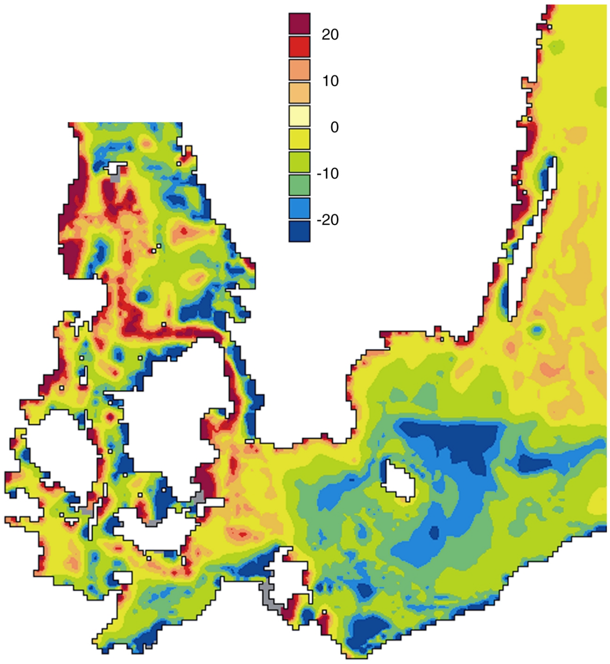


Fig.3.2.9. Upelling/downwelling indexes in percentages in the Danish Straits.

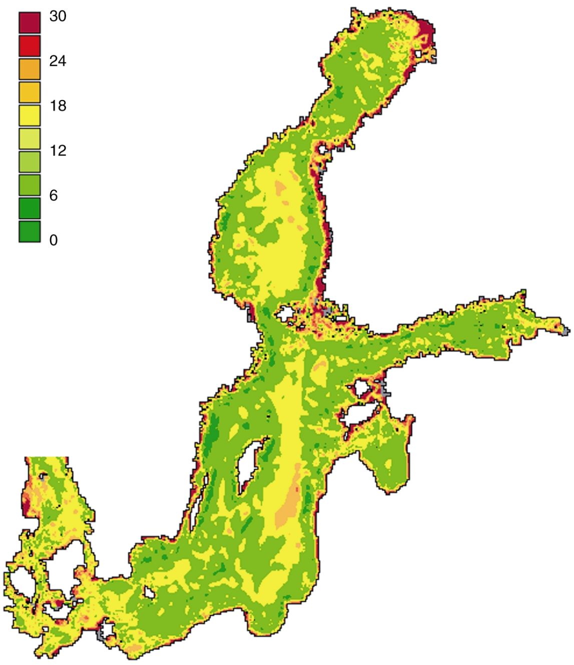


Fig. 3.2.10. The rms of the upwelling index in percentages.

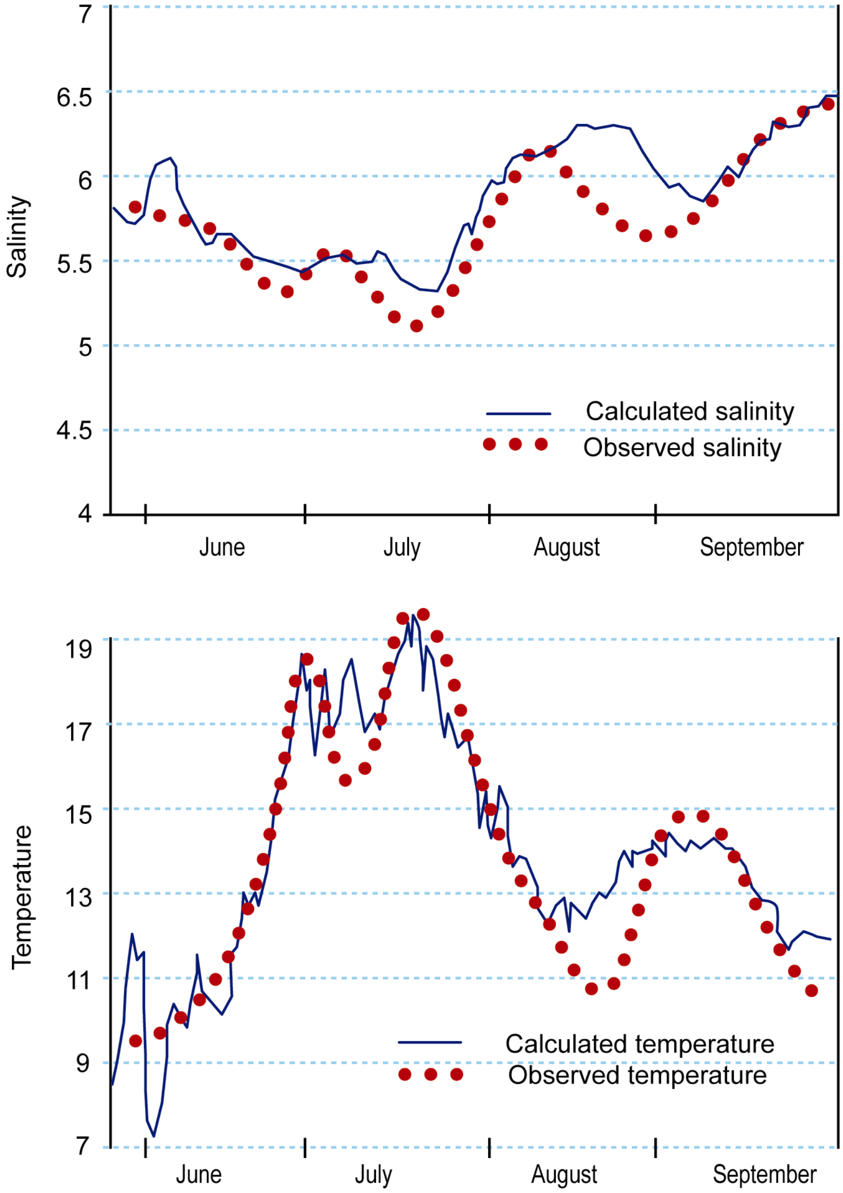


Fig. 3.2.11. Upper figure: the measured (dotted) and simulated (solid) surface salinity in psu (5 m depth) near the Hanko Peninsula in the Gulf of Finland in June –September 1988 (measurements from Haapala,1994). Lower figure: the same as the upper one but for temperature (°C).

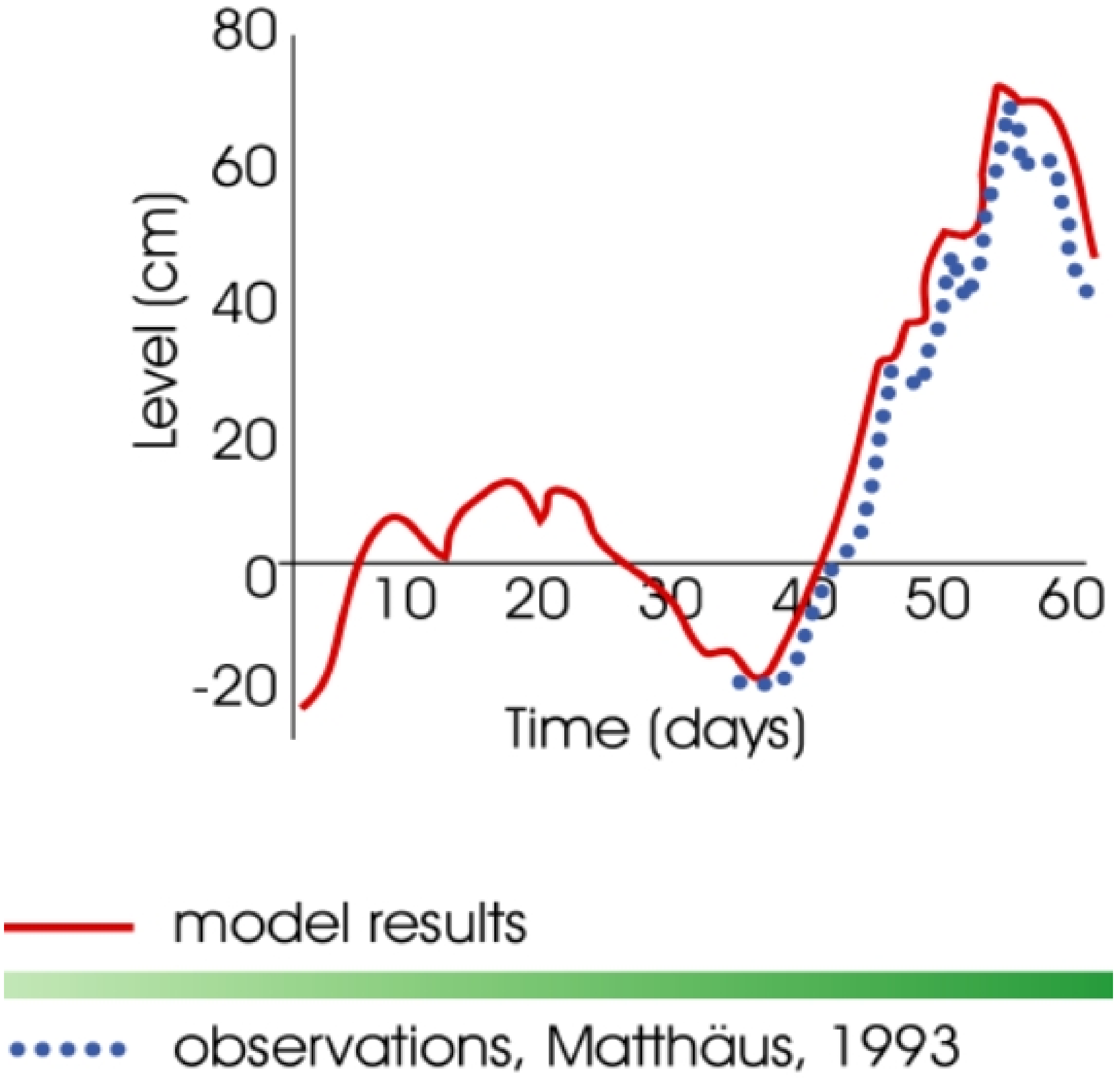


Fig. 3.2.12. Modelled and measuered sea-levels in Landsort (model results from December 1 1992 to January 31, 1993).

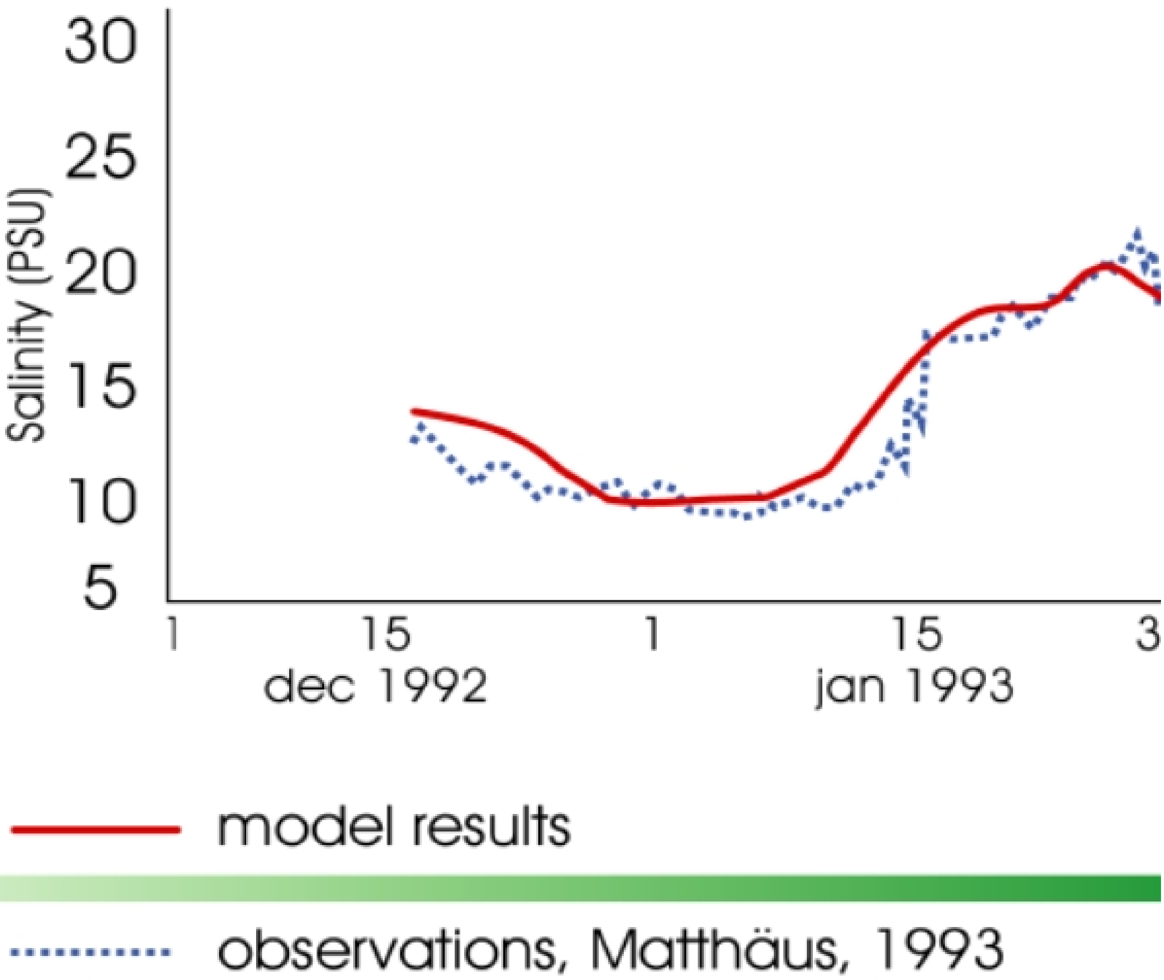


Fig. 3.2.13. Vertical averages of the daily mean salinity in Darss from December 16, 1992 onwards.

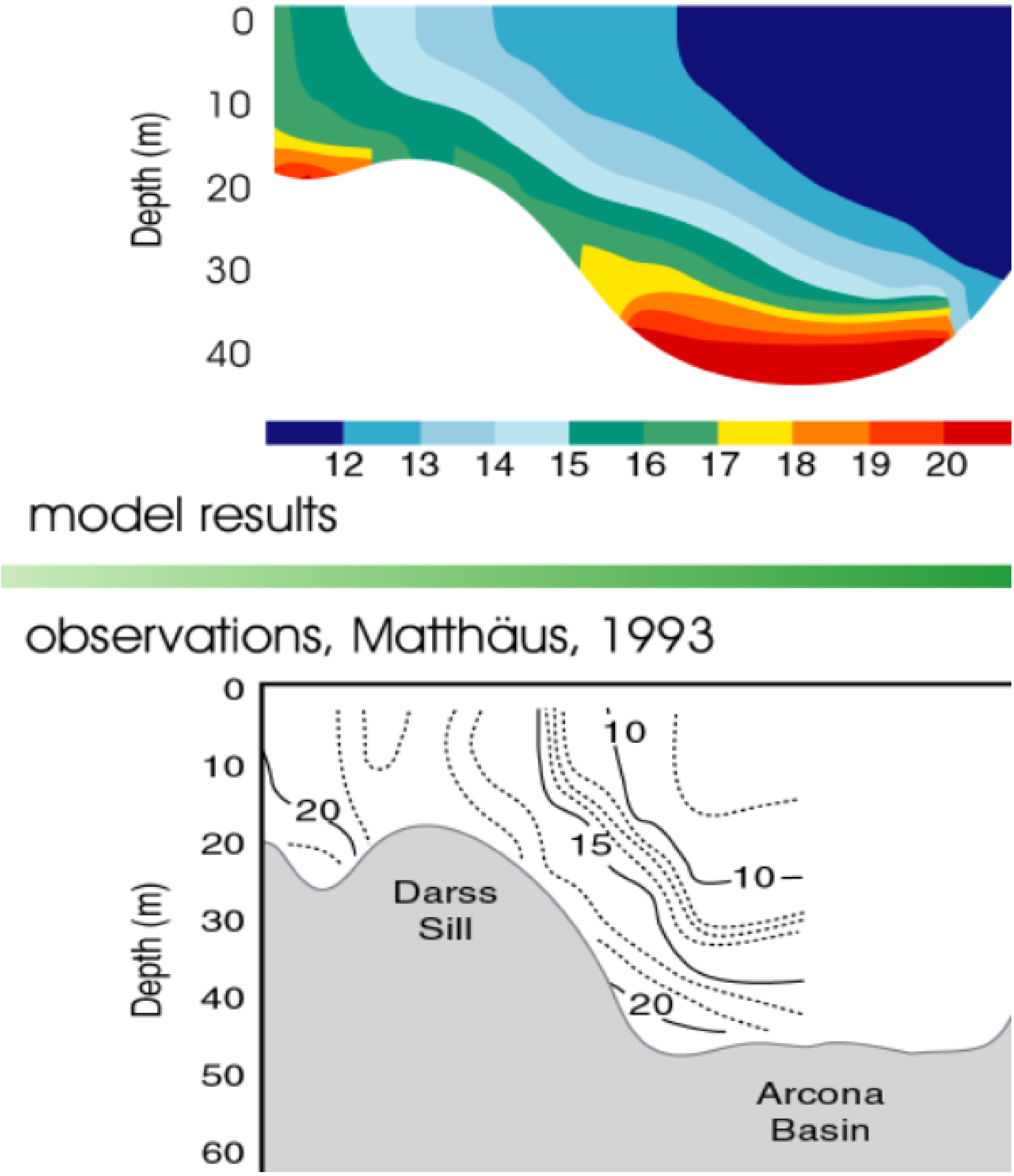


Fig. 3.2.14. Salinity cross-section Darss-Arkona Basin on January 20, 1993.

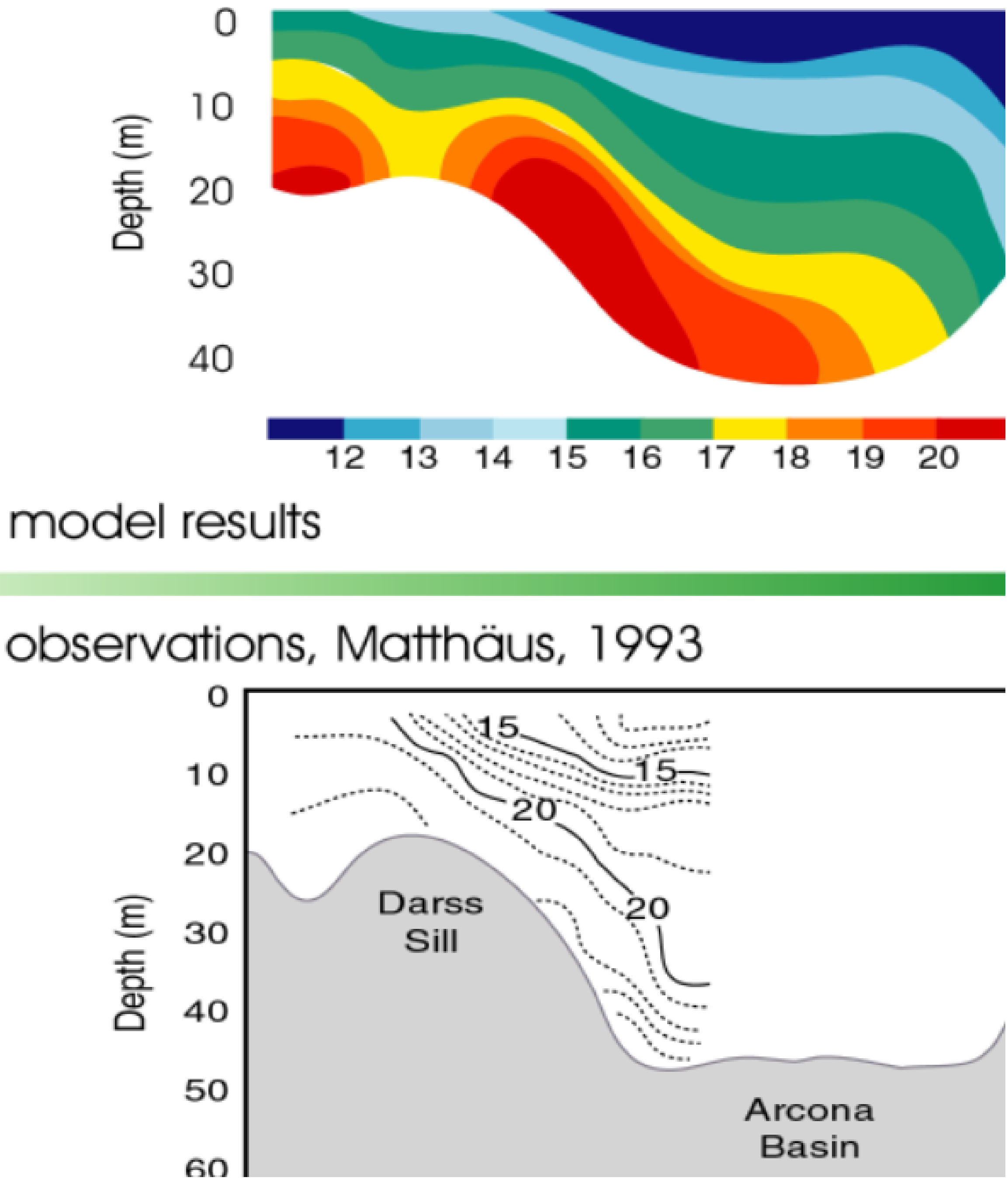


Fig. 3.2.15. Salinity cross-section Darss-Arkona Basin on January 27, 1993.

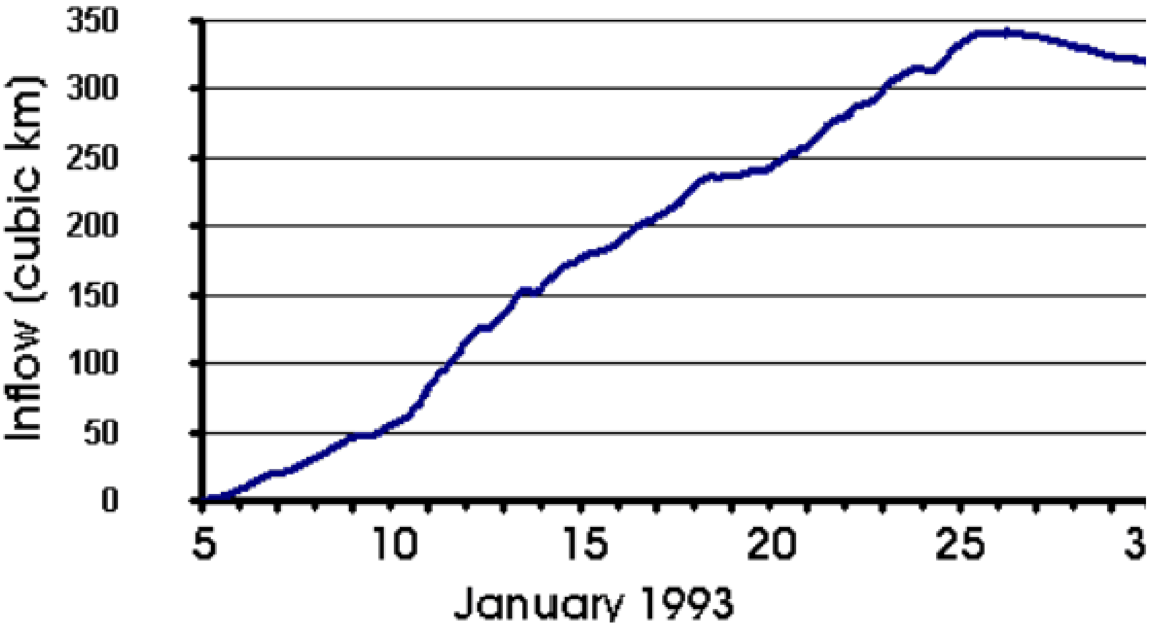
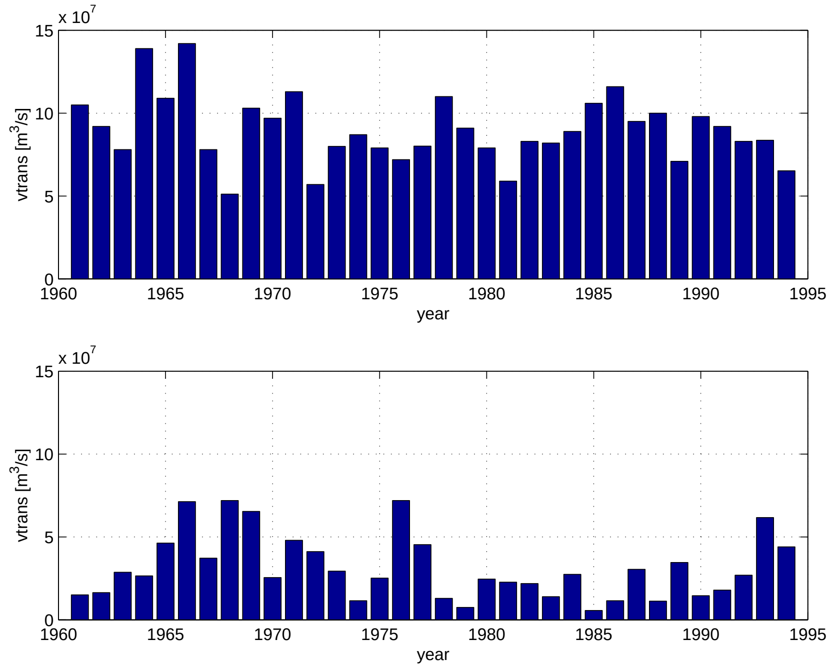


Fig. 3.2.16. The volume of water flowed into the Baltic Sea during the inflow period

a)



b)

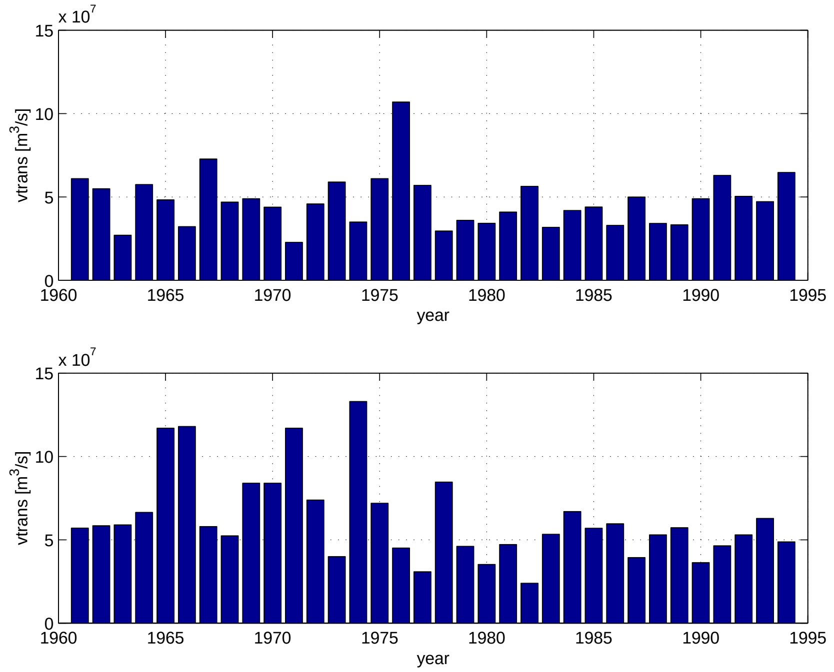


Fig. 3.2.17. Quarterly integrated upwelling transport derived from horizontal Ekman transports a) 2nd quarter of the years with upper pannel - northern coast and lower pannel southern coast of the Bornholm Basin and b) 3rd quarter of the years with upper pannel - northern coast and lower pannel southern coast of the Bornholm Basin

a)

b)

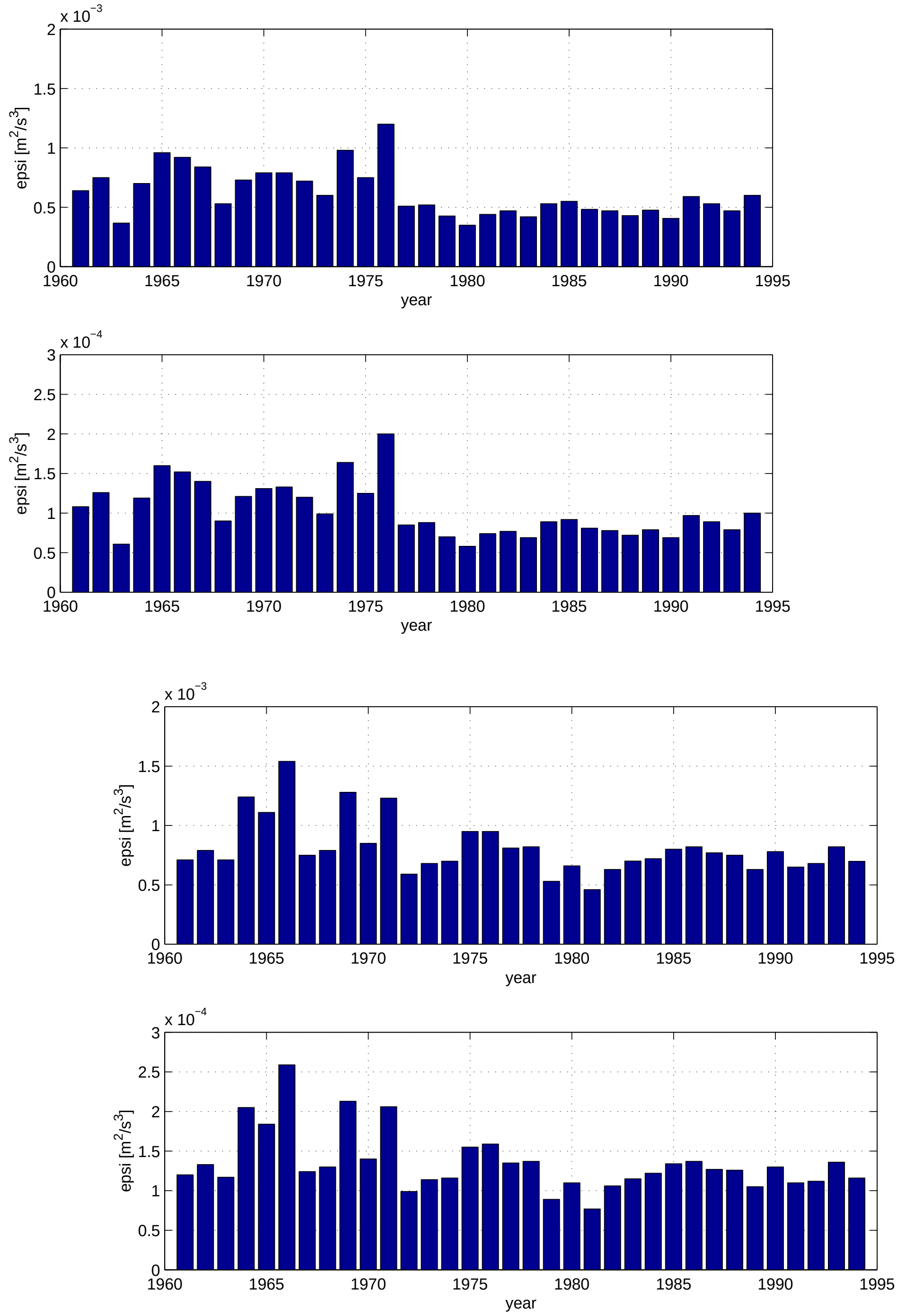


Fig. 3.2.18. Quarterly averaged dissipation rate of turbulent kinetic energy a) 2nd quarter of the years with upper pannel for larval sprat (0-10m) and lower panel for larval cod (25-35m) and b) 3rd quarter of the years with upper pannel for larval sprat (0-10m) and lower pannel for larval cod (25-35m).

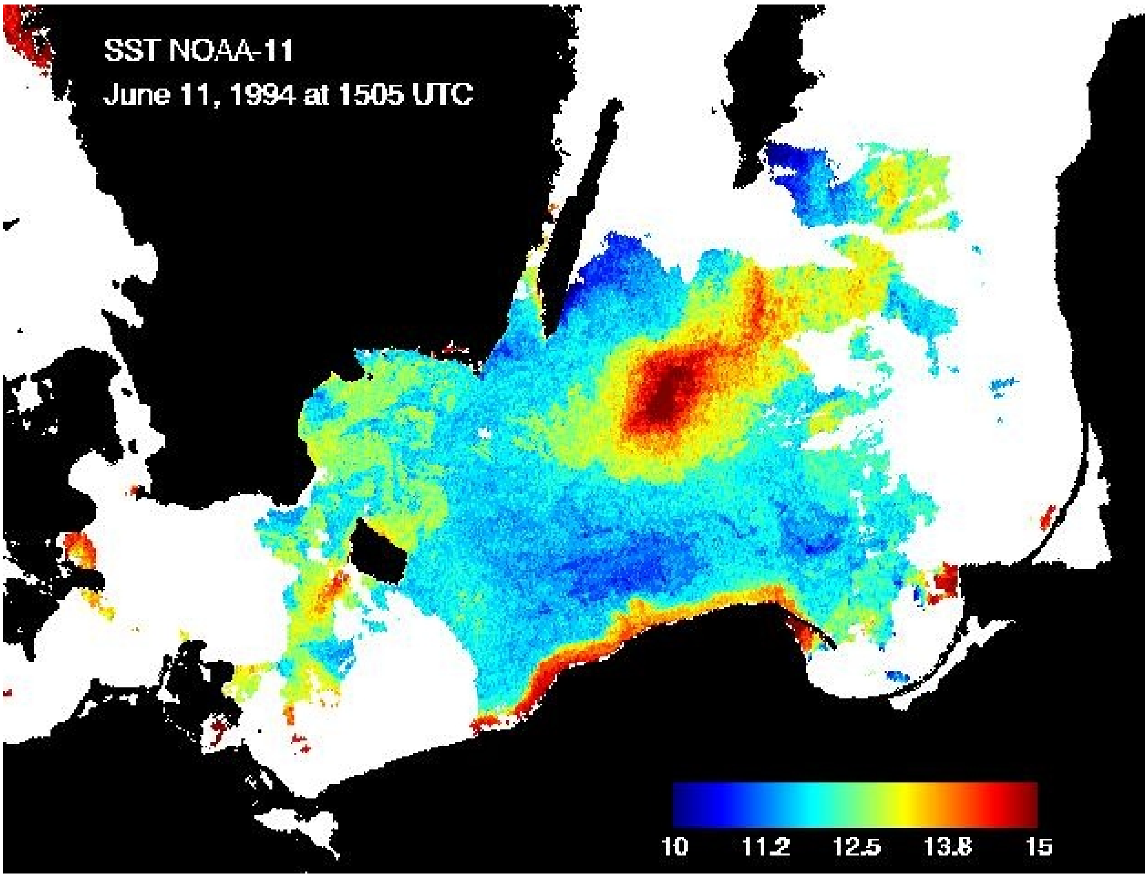


Fig. 3.2.19. Sea surface temperature obtained from AVHRR satellite imagery , June 11, 1994.

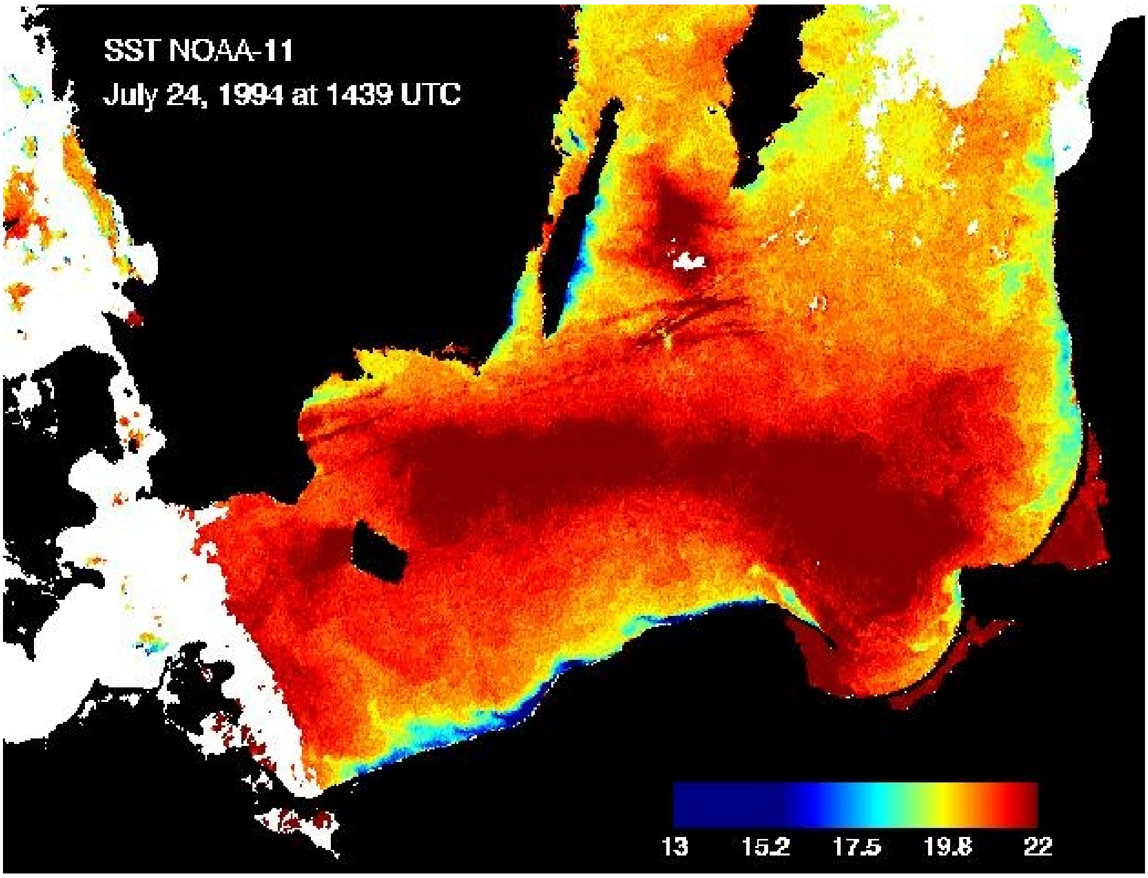


Fig. 3.2.20. Sea surface temperature obtained from AVHRR satellite imagery , July 24, 1994.

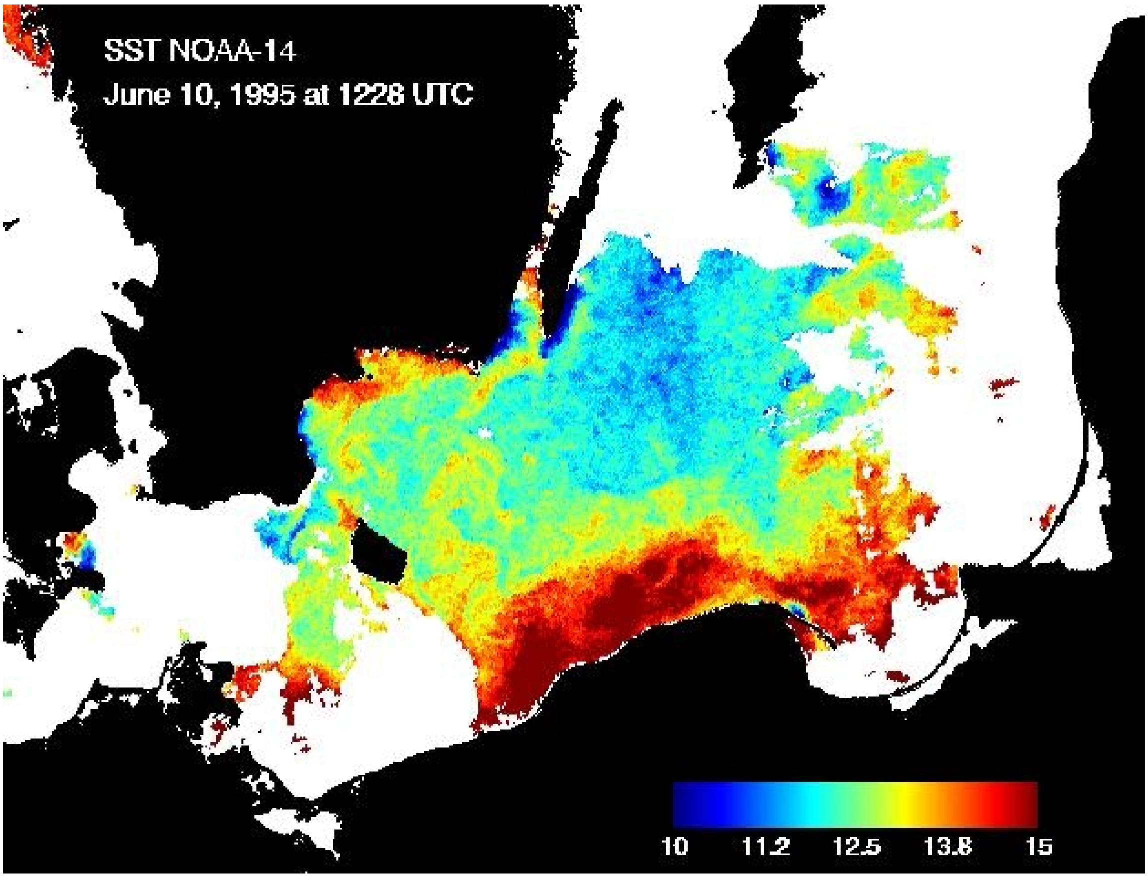


Fig. 3.2.21. Sea surface temperature obtained from AVHRR satellite imagery , June 10, 1995.

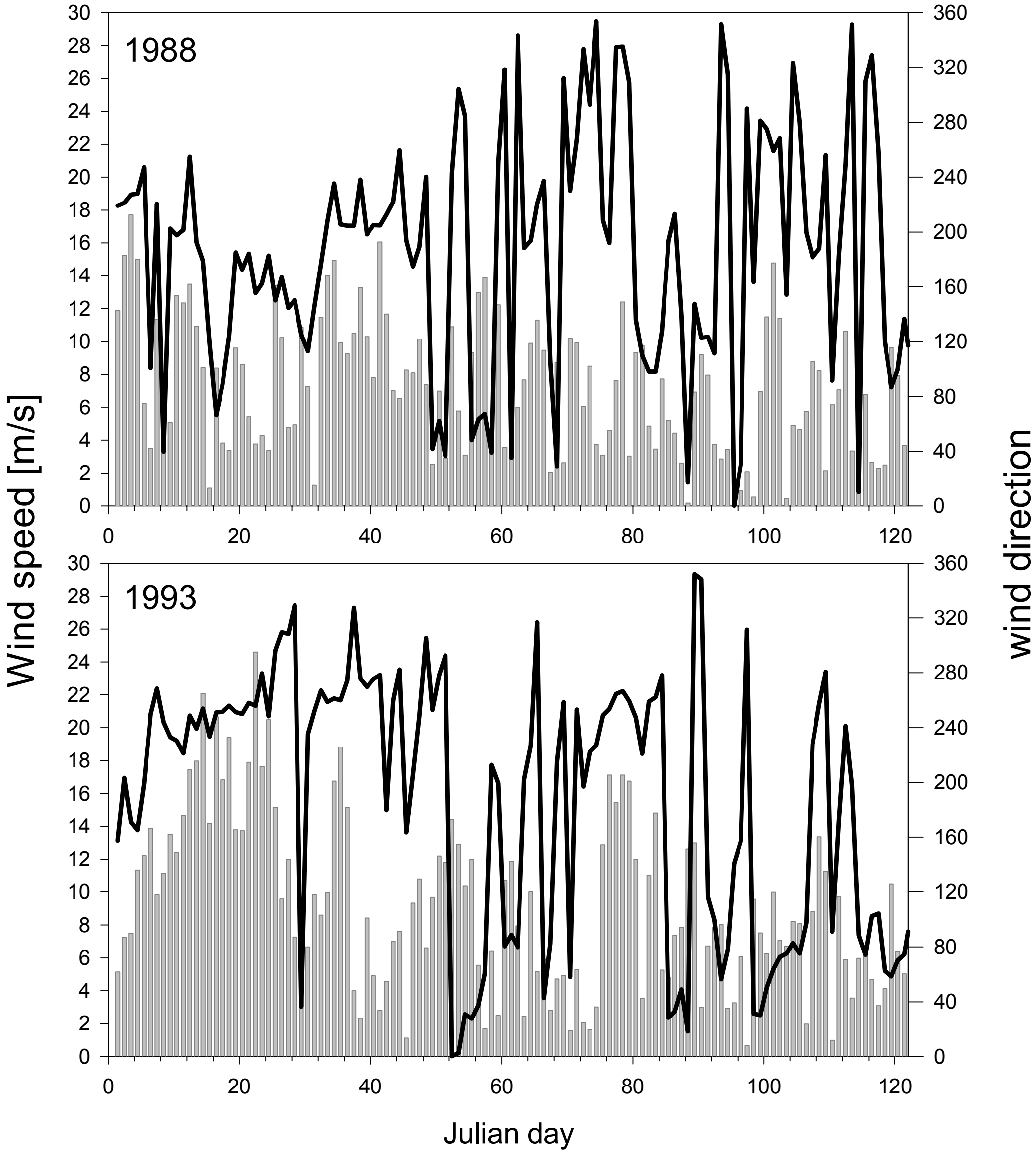


Fig. 4.1: Daily mean wind direction and wind speed from January to April 1988 and 1993 taken from Christiansø weather station (line - wind direction; histogram bars – wind speed).

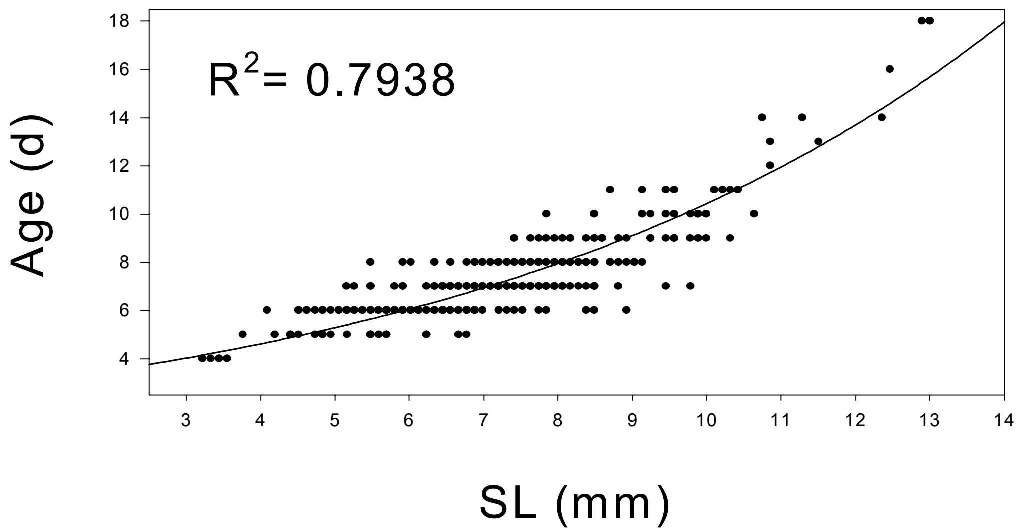


Fig. 4.2: Measured lengths of larvae related to larval age obtained from otolith microstructure analysis.

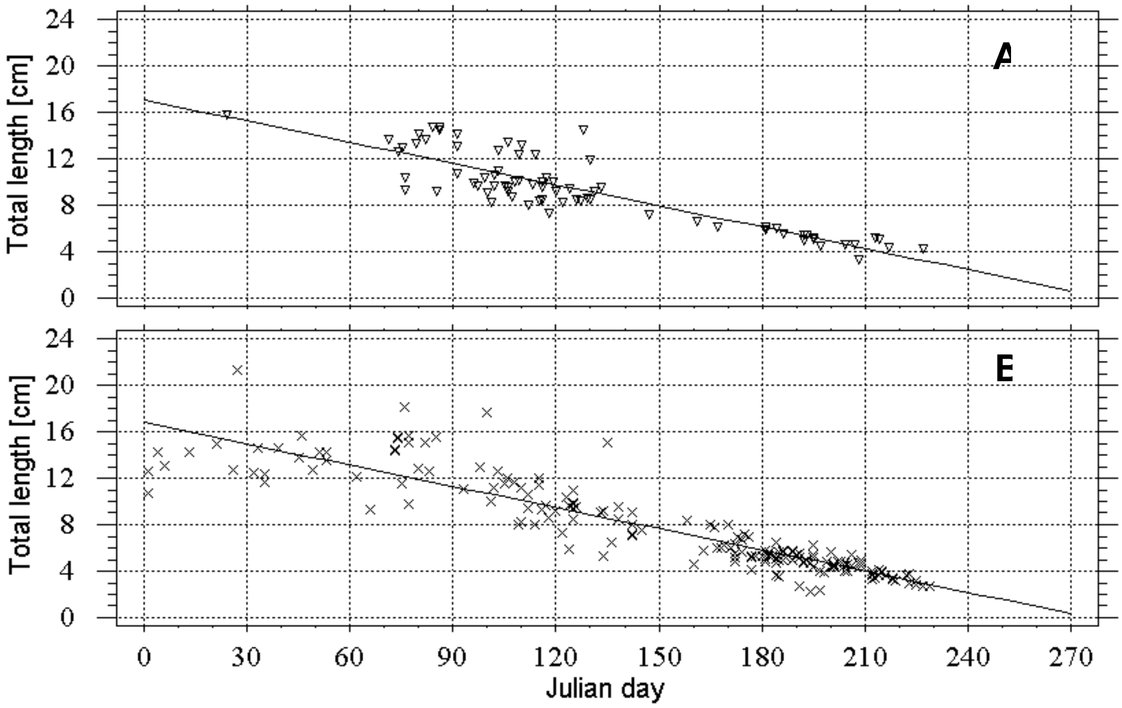


Fig. 4.3: Distribution of total lengths and birthdates for juvenile cod caught from 1993 to 1996 in a) the Arkona Basin, and b) the Bornholm Basin with lines representing linear regressions.

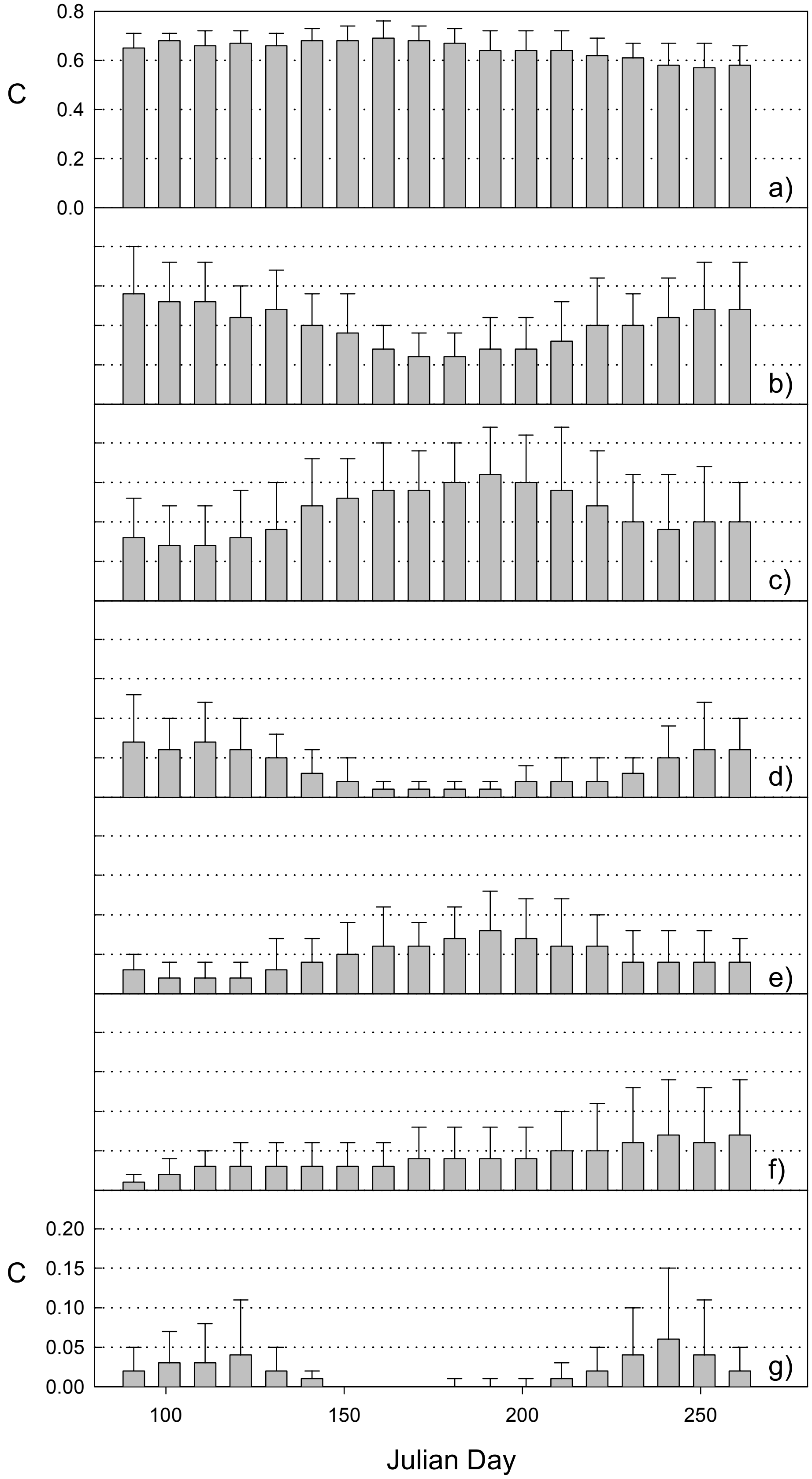


Fig. 4.4: Averaged seasonal residence probability of larval cod in different subareas of the Central Baltic expressed by overlap coefficients (1986-1999); a) depths >60m, b) depths 40-60m south, c) depths 40-60m north, d) <40m depths south, e) depths < 40m north, f) west of 14 E, and g) east of 18 E; bars showing mean values and solid lines its standard deviations.

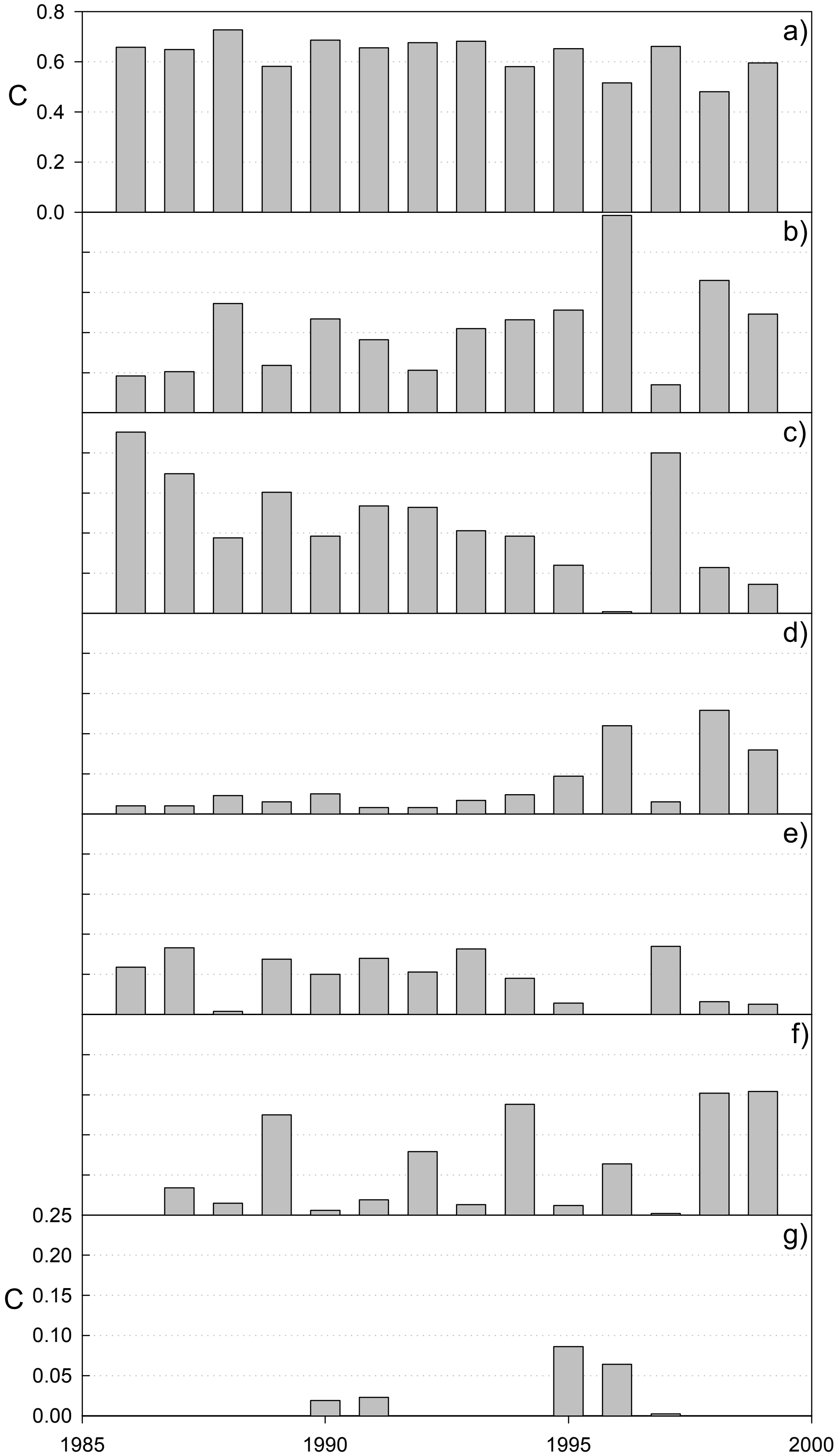


Fig. 4.5: Occurence of larval cod in different subareas of the Bornholm Basin after peak spawning expressed by overlap coefficients (1986-1999) a) depths >60m, b) depths 40-60m south, c) depths 40-60m north, d) <40m depths south, e) depths < 40m north, f) west of 14 E, and g) east of 18 E.

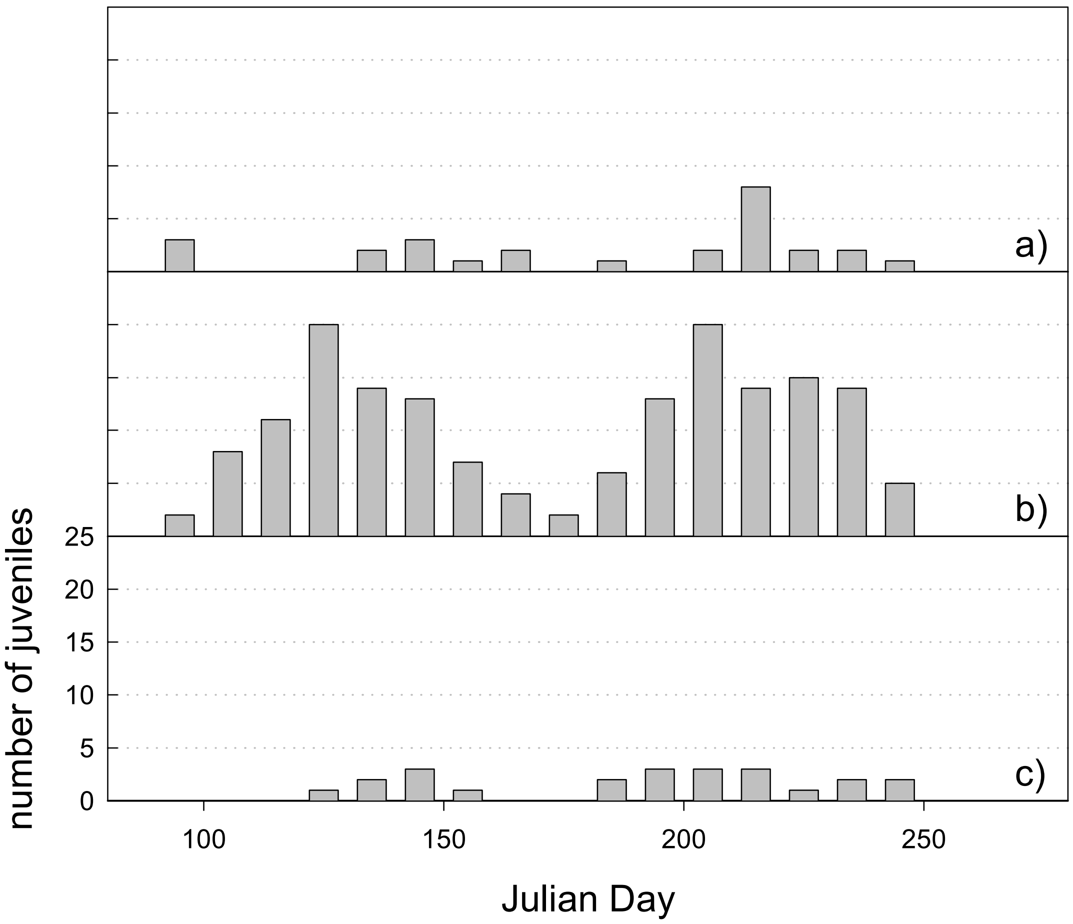


Fig. 4.6: Demersal 0-group cod caught in different areas of the Bornholm Basin according to birthdates (1993-1996), a) depths <40m north, b) depths <40m south, and c) depths >40m deep basin.

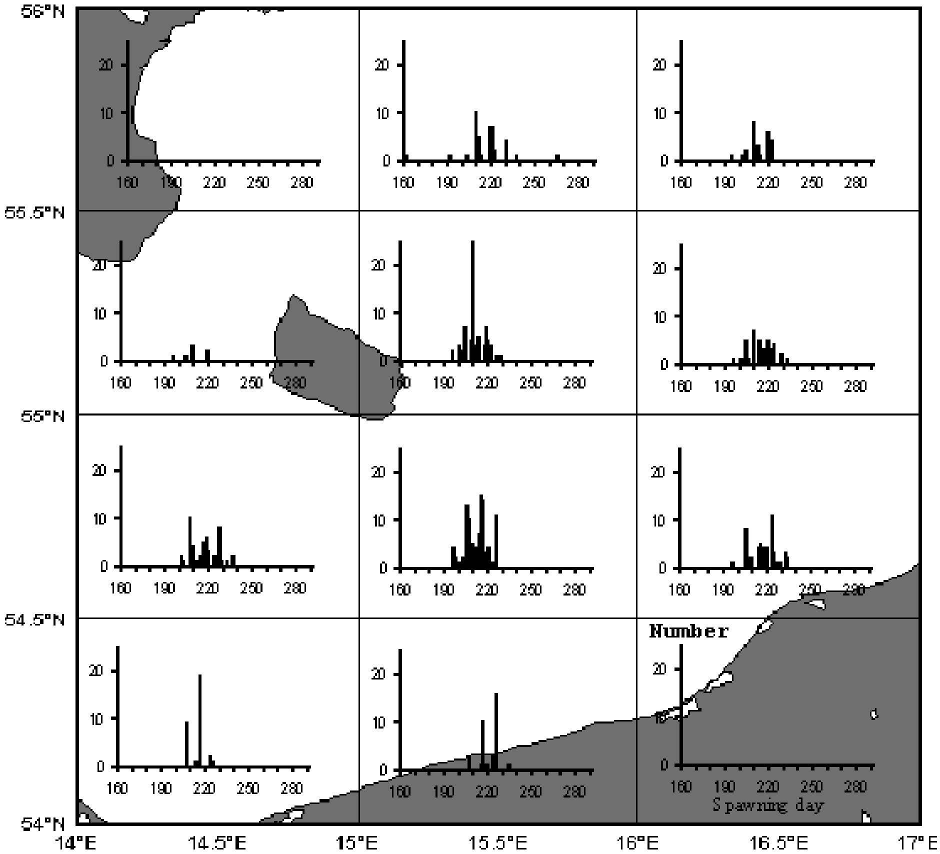
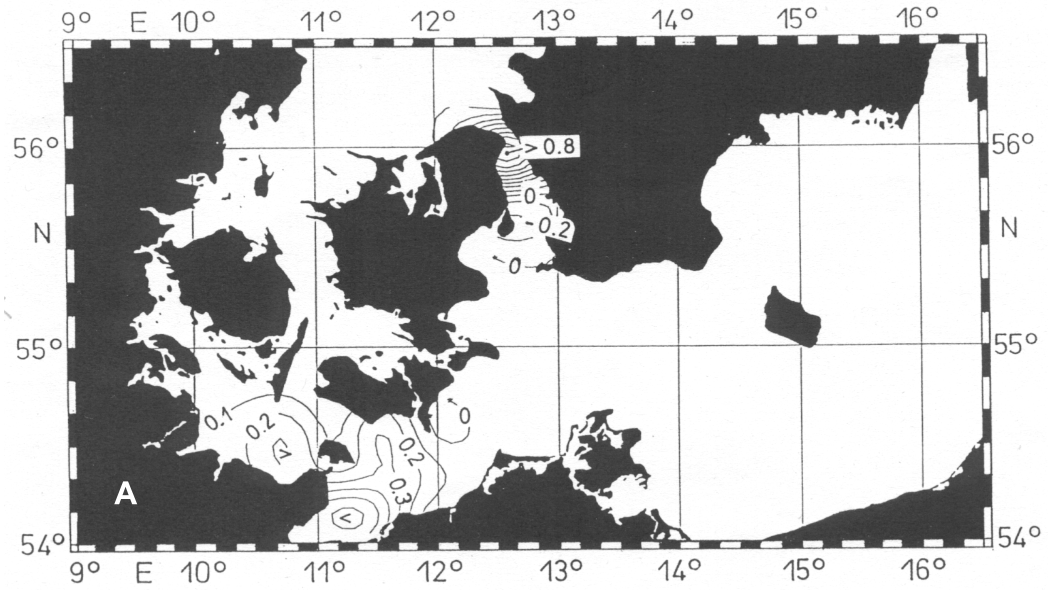


Fig. 4.7: Age distribution of pelagic 0-group cod per rectangle.



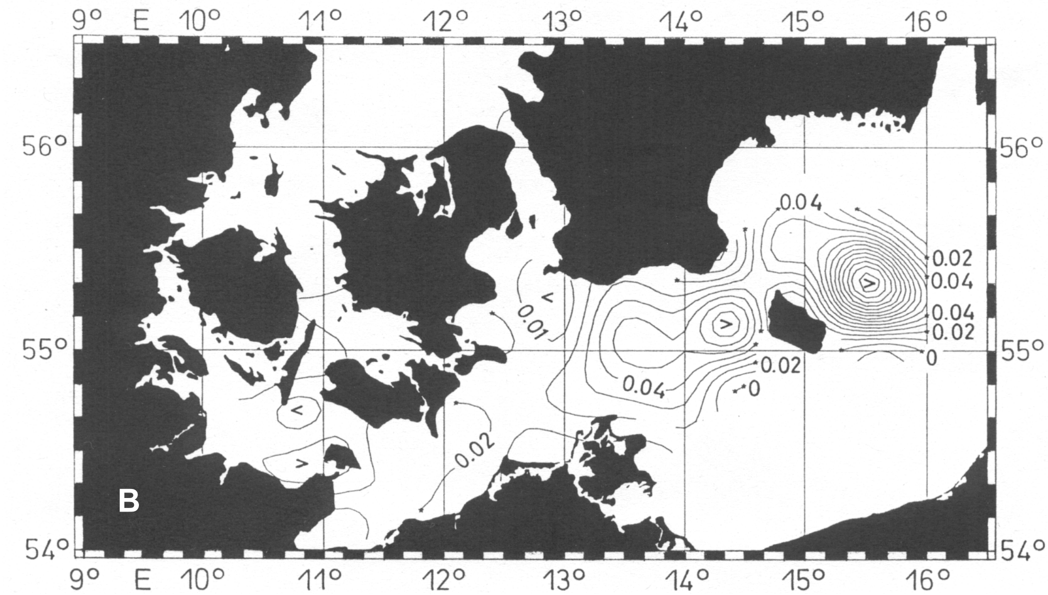
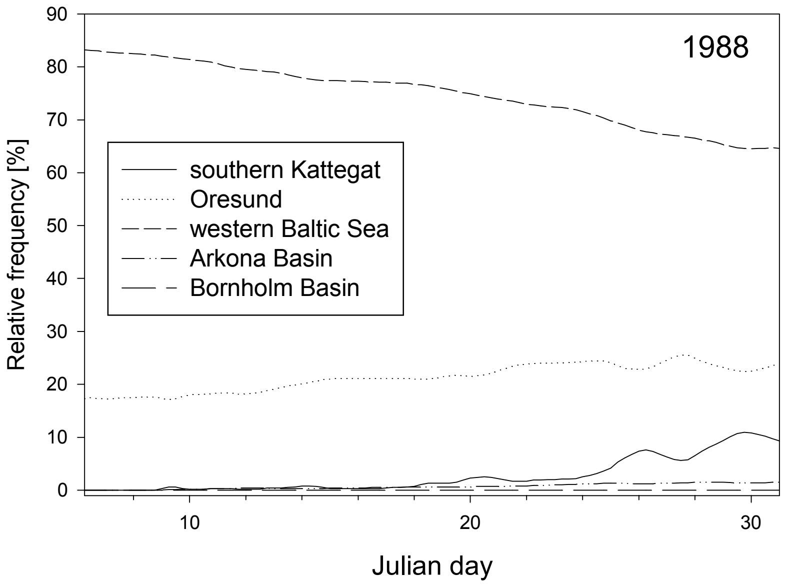


Fig. 4.8: Horizontal distribution of tracers representing cod eggs and young larvae initially released within the spawning grounds of the western Baltic cod stock on 5 January of each year at a) the end of January 1988 (contour interval 0.1 n/m^3), and b) the end of January 1993 (contour interval 0.01 n/m^3).



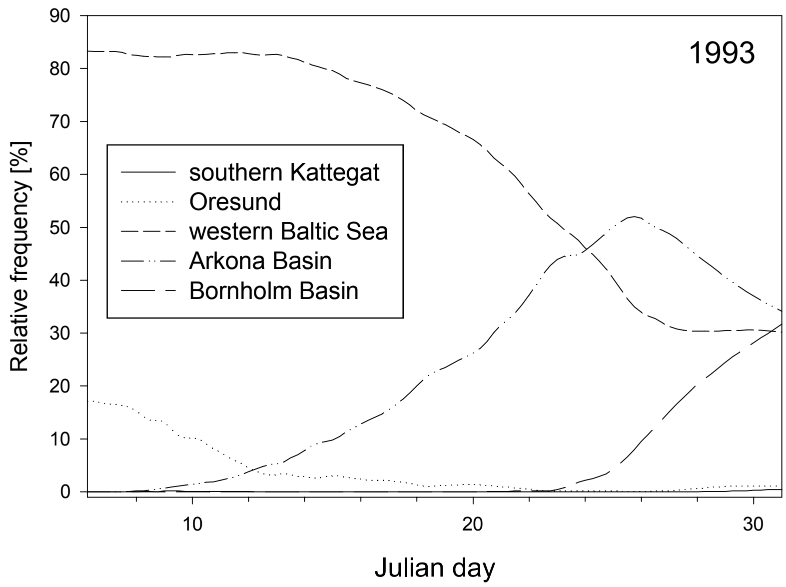


Fig. 4.9: Time series (January 1988 and 1993) of relative frequency of cod eggs and young larvae initially released as tracers in the western Baltic ending their drift within different areas of the Baltic.

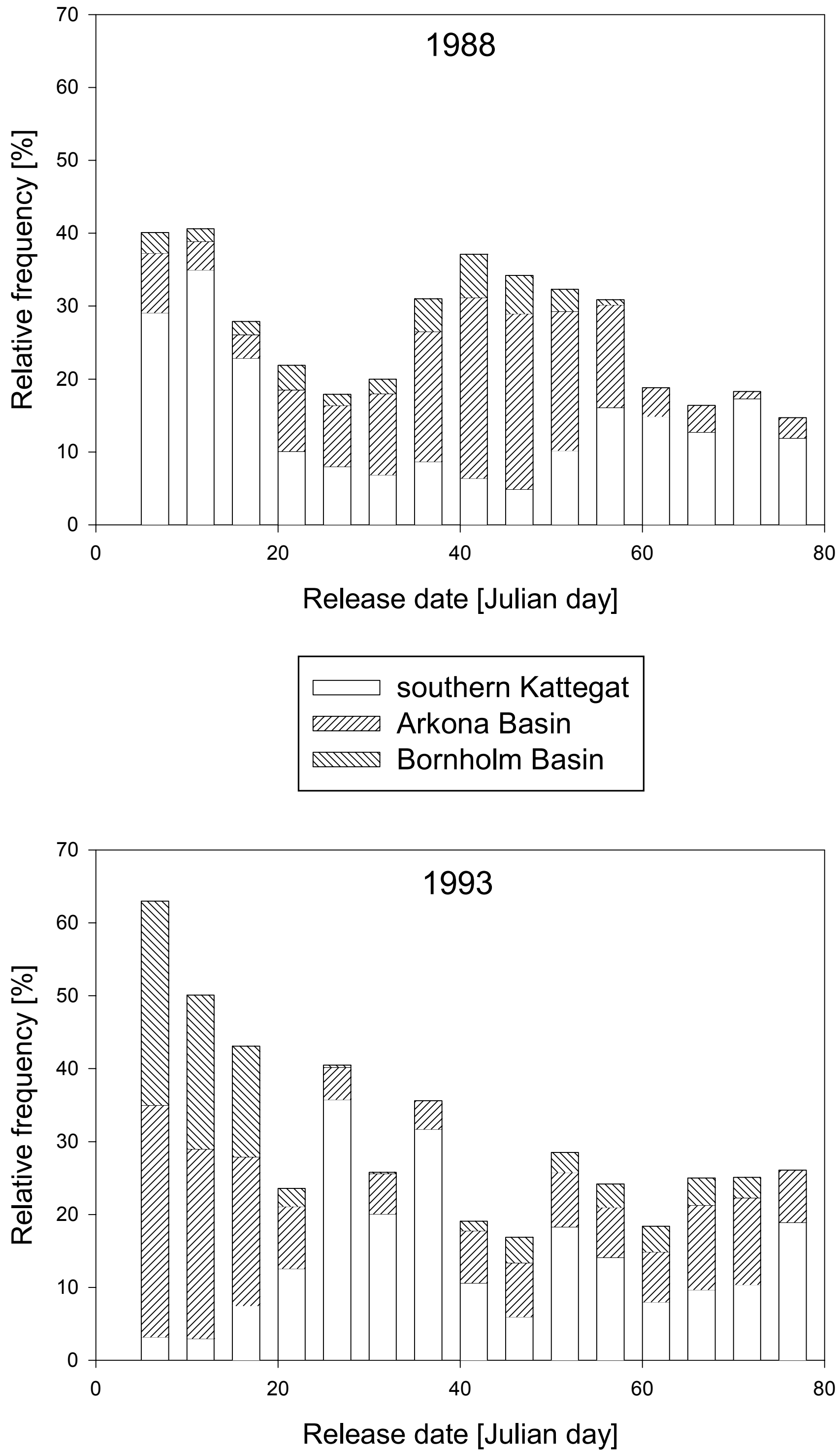


Fig. 4.10: Time series (January to March 1988 and 1993) of relative frequency of Lagrangian drifters (drift duration 45 days) ending their drift within the southern Kattegat, the Arkona Basin, and the Bornholm Basin. The x-axis indicates the dates of release.

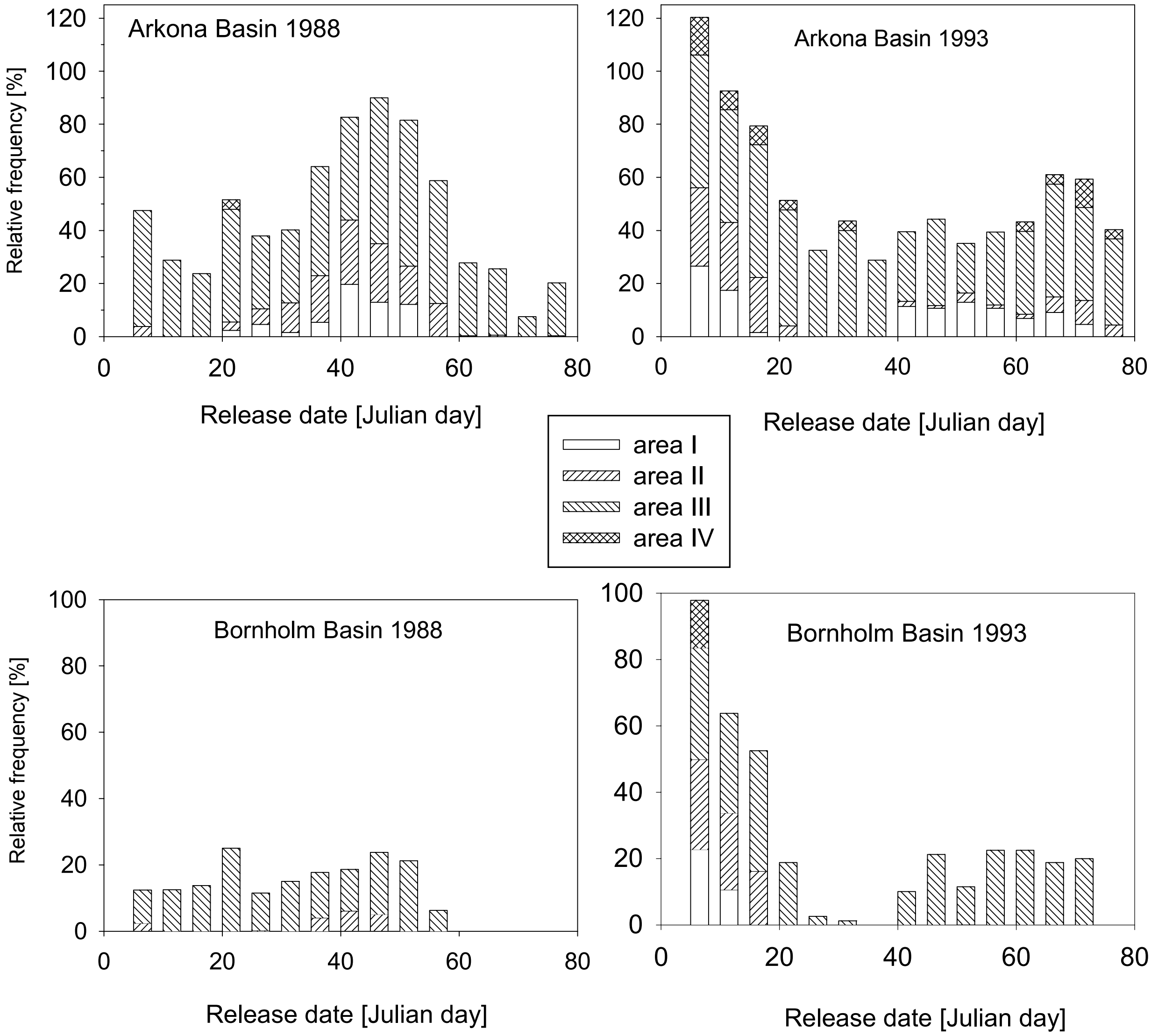


Fig. 4.11: Time series (January to March 1988 and 1993) of relative frequency of Lagrangian drifters (drift duration 45 days) destined for the Arkona and the Bornholm Basin and initially released (see Fig. 3.2) in the Great Belt (I); the Little Belt, Kiel Bay, Langeland Belt and Fehmarn Belt (II); Mecklenburg Bay (III); and the Øresund (IV).

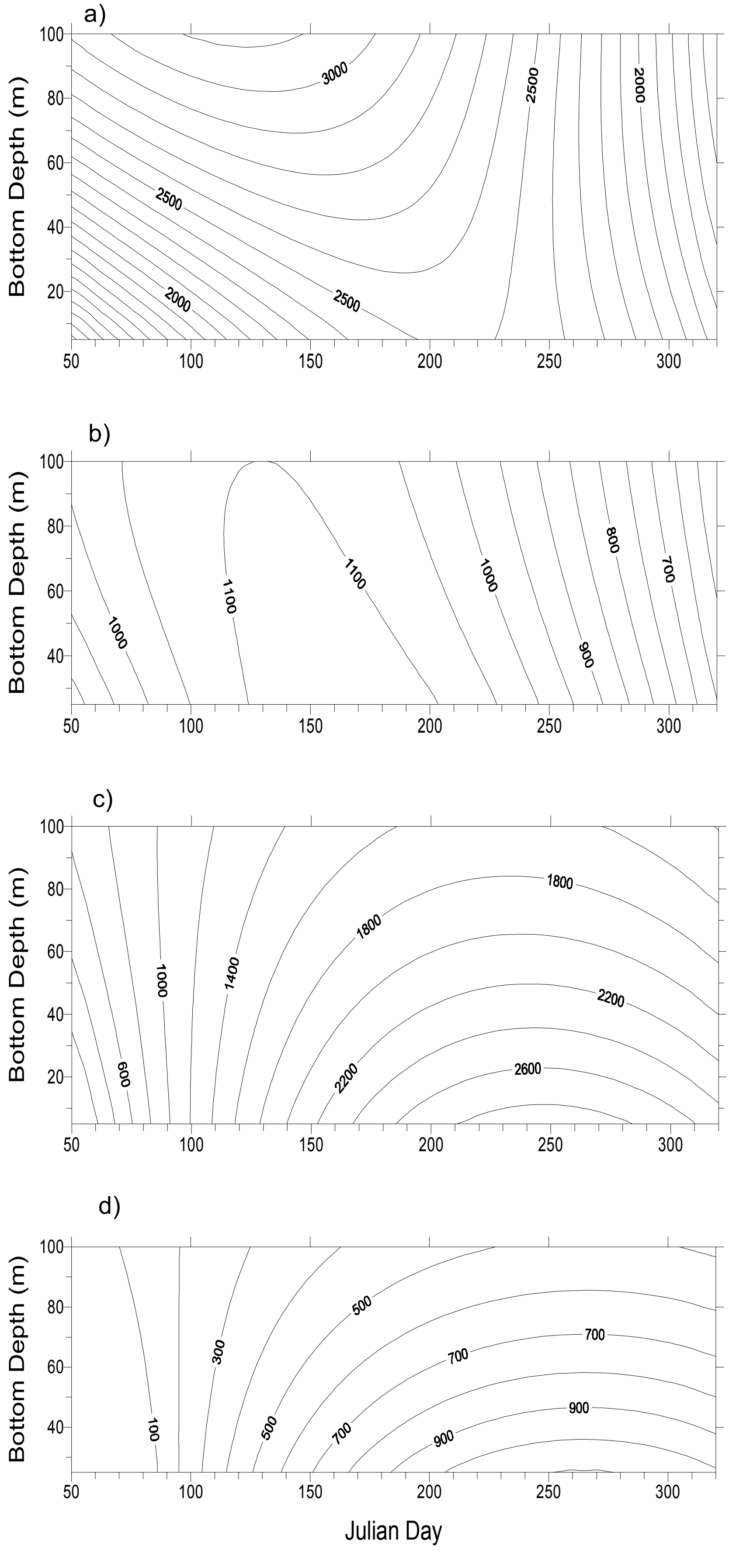


Fig. 4.12: Idealized mean nauplii prey fields according to date and bottom depth, a) incl. *P. elongatus* (0-25m); b) incl. *P. elongatus* (25-50m); c) excl. *P. elongatus* (0-25m); and d) excl. *P. elongatus* (25-50m).

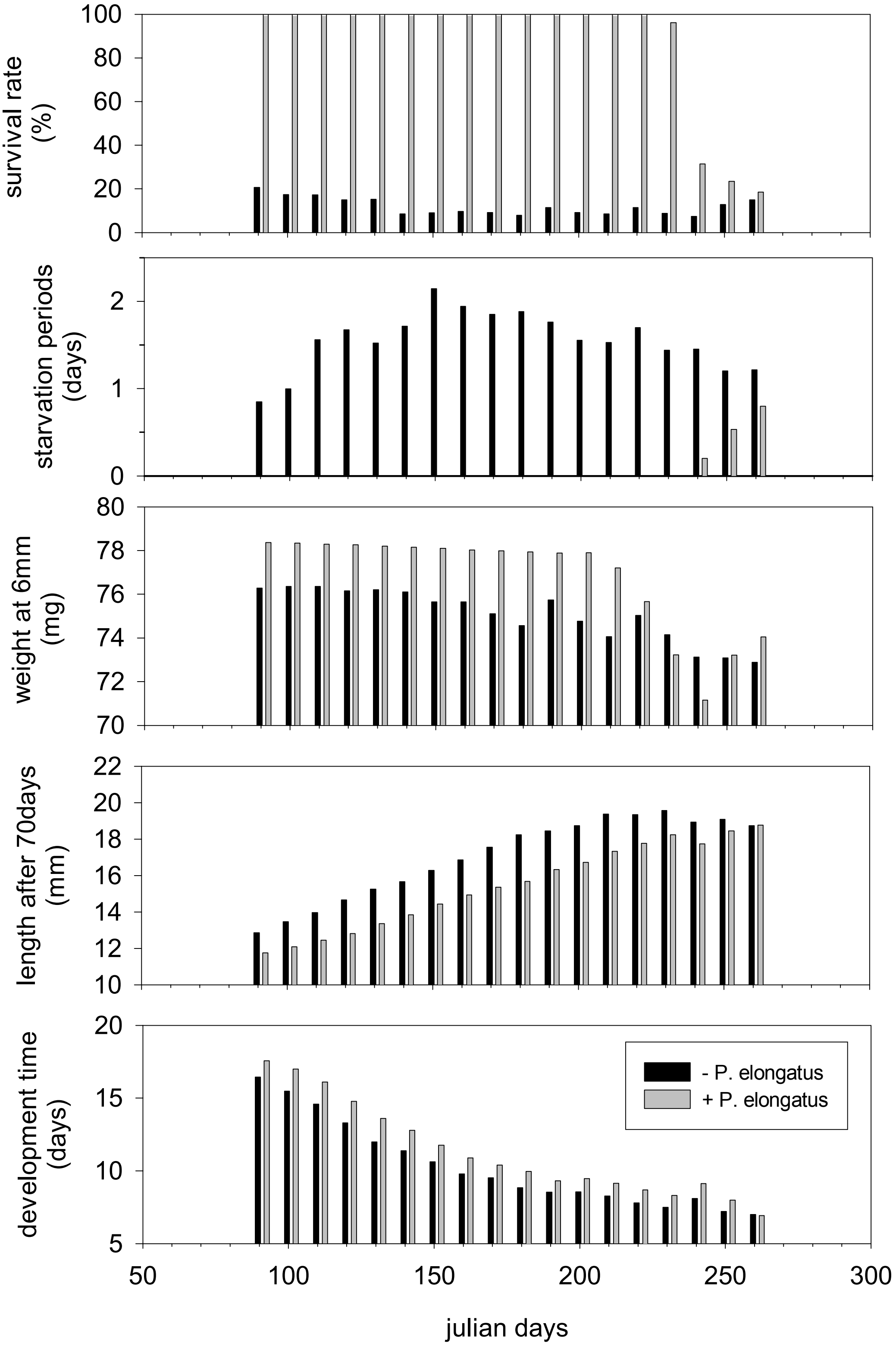


Fig. 4.13a: Averaged (1986-1999) seasonal model output parameters of surviving larvae obtained from simulations with (+) and without (-) *P. elongatus*: survival rate, starvation periods, mean weight at 6 mm length, length after 70 days of drift and feeding as well as the development time until the end of the first-feeding stage.

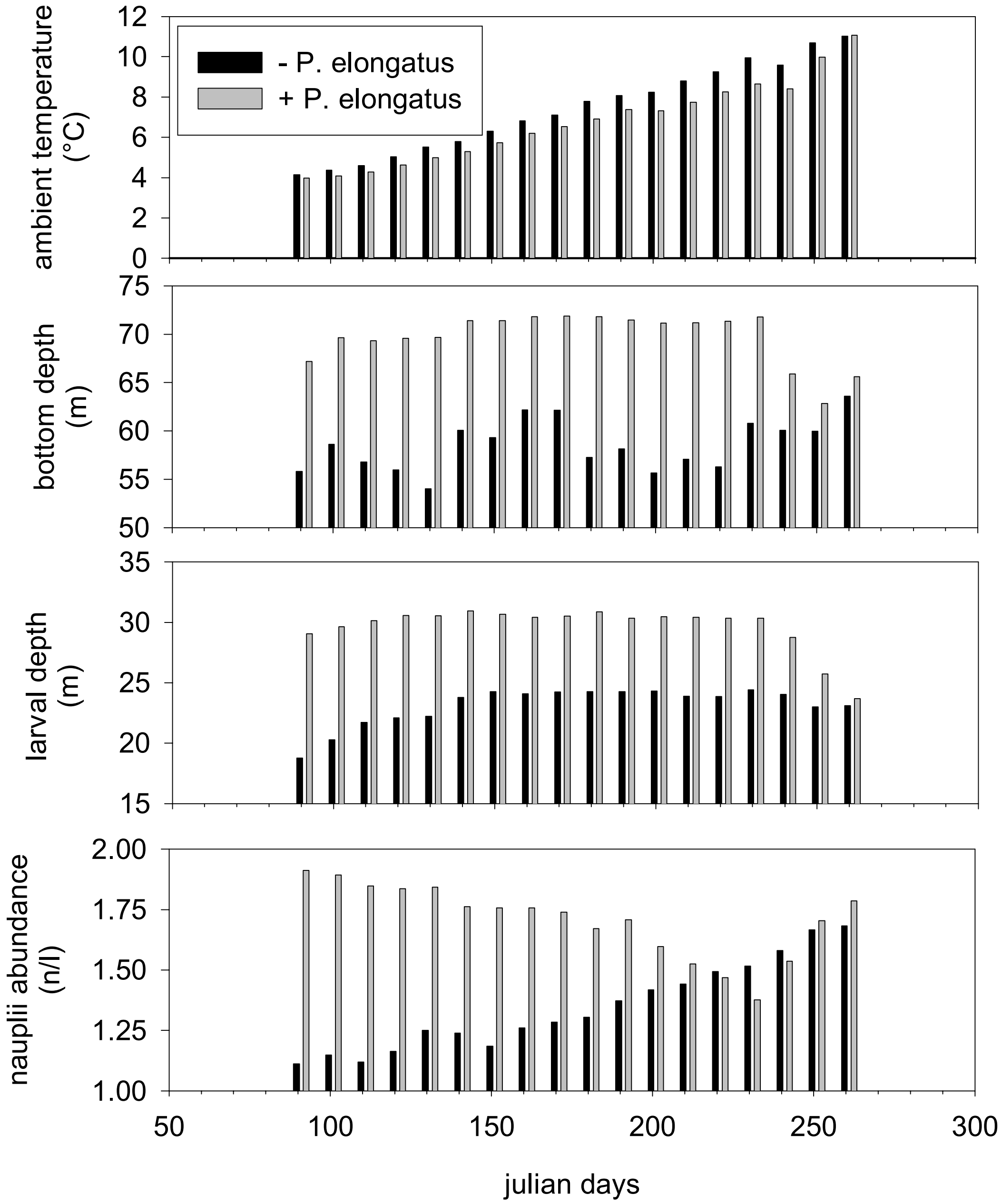


Fig. 4.13b: Averaged (1986-1999) seasonal ambient environmental variables of surviving larvae obtained from simulations with (+) and without (-) *P. elongatus*: ambient temperature, bottom depth, larval depth and nauplii abundance.

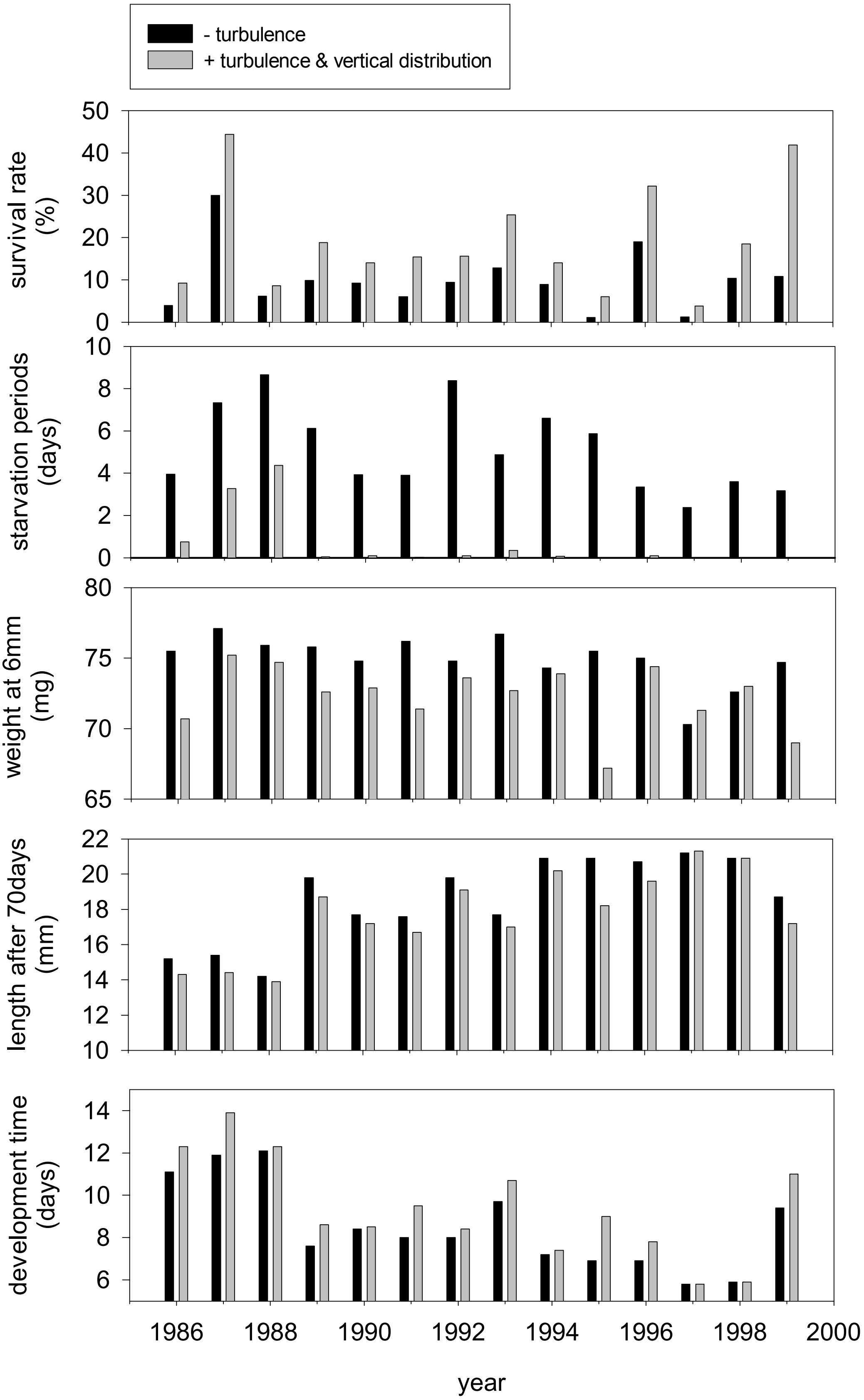


Figure 4.14a: Time-series (1986-1999) of model output parameters of surviving larvae originating from peak spawning obtained from simulations without *P. elongatus*, without (-) and with (+) turbulence and adjustment in zooplankton vertical distribution: survival rate, starvation periods, mean weight at 6 mm length, length after 70 days of drift and feeding as well as the development time.

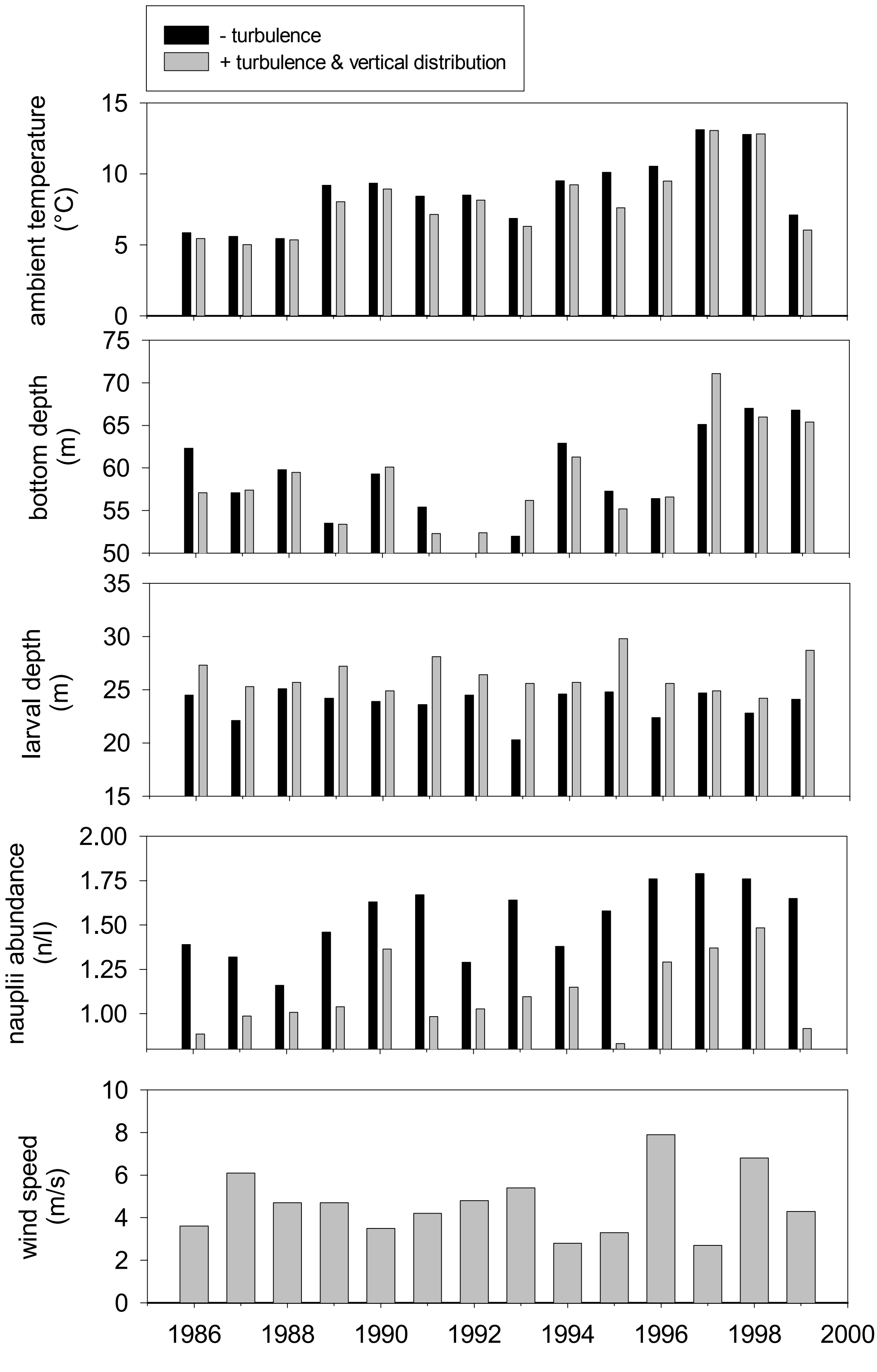


Figure 4.14b: Time-series (1986-1999) of ambient environmental variables of surviving larvae obtained from simulations without *P. elongatus*, without (-) and with (+) turbulence and adjustment in zooplankton vertical distribution: ambient temperature, bottom depth, larval depth and nauplii abundance; and additionally wind speed.

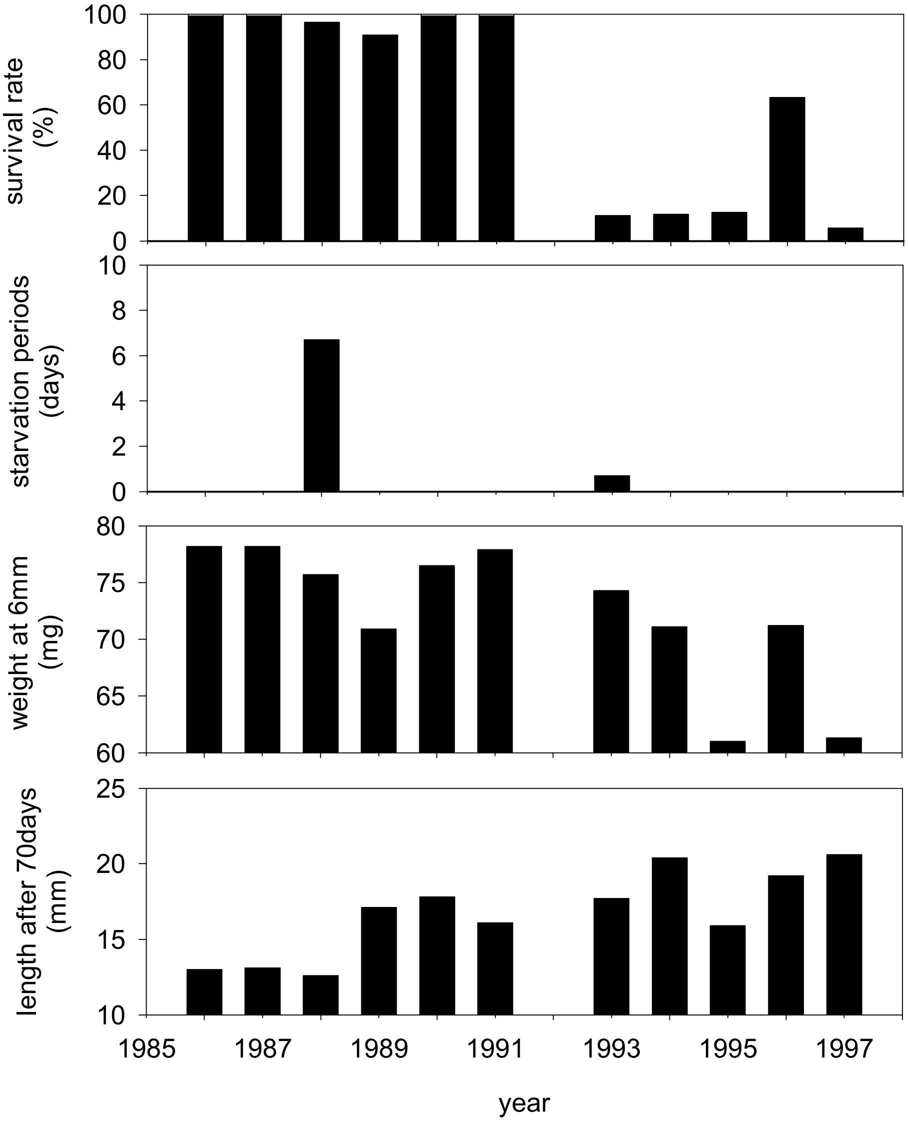


Fig. 4.15: Time series (1986-1997; 1992-no data) of model output parameters of surviving larvae originating from peak spawning obtained from simulations with weighted nauplii abundance including *P. elongatus*, turbulence and adjustment in zooplankton vertical distribution: survival rates, starvation periods, mean weight at 6 mm length and length after 70 days of drift and feeding.

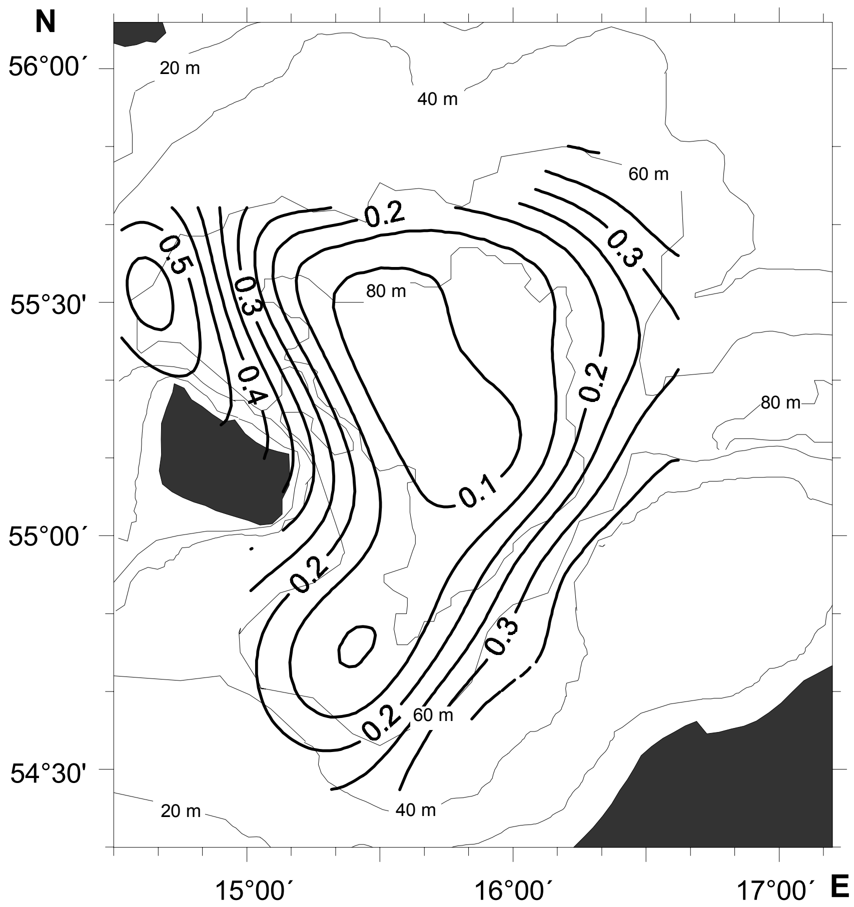


Fig. 4.16: Average (1986-1999) horizontal distribution of mean larval survival probability in the Bornholm Basin obtained from simulations without *P. elongatus* and the impact of turbulence.

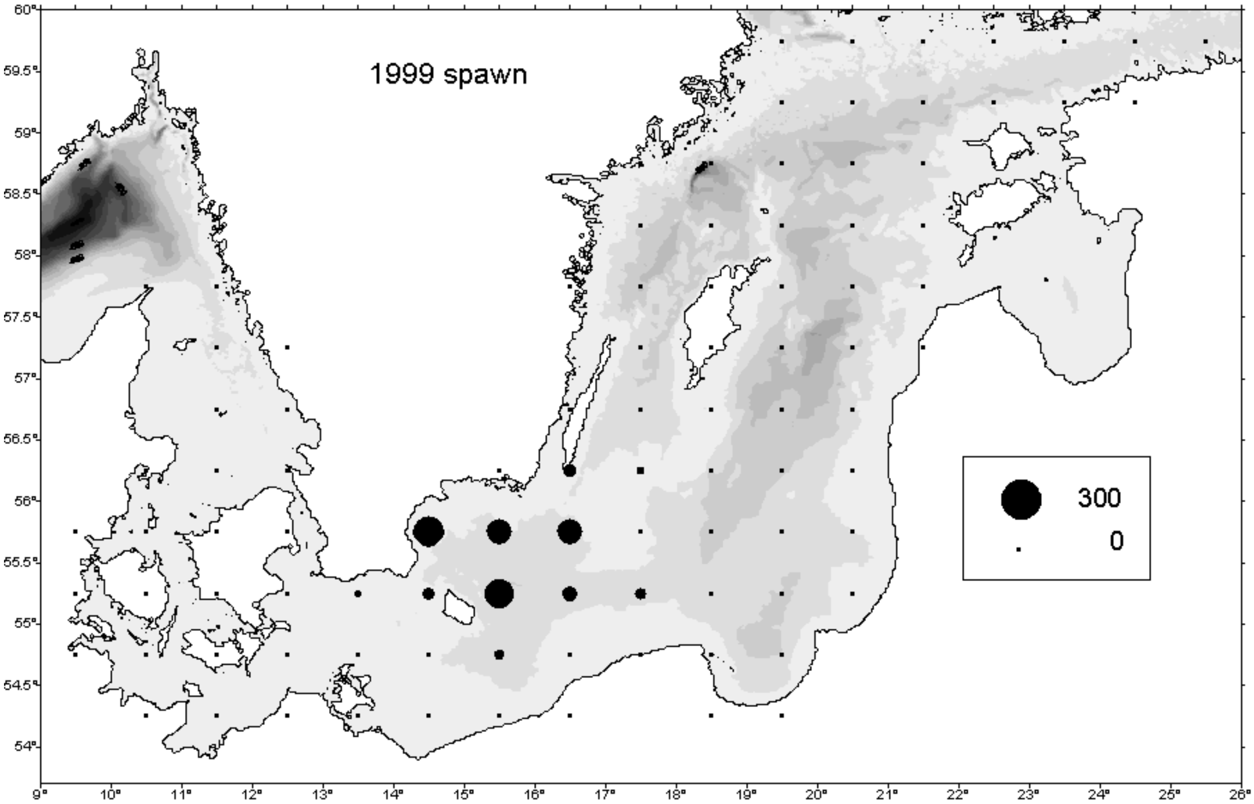


Fig. 4.17: Back-calculated spawning locations for sprat caught as larvae in May 1999.

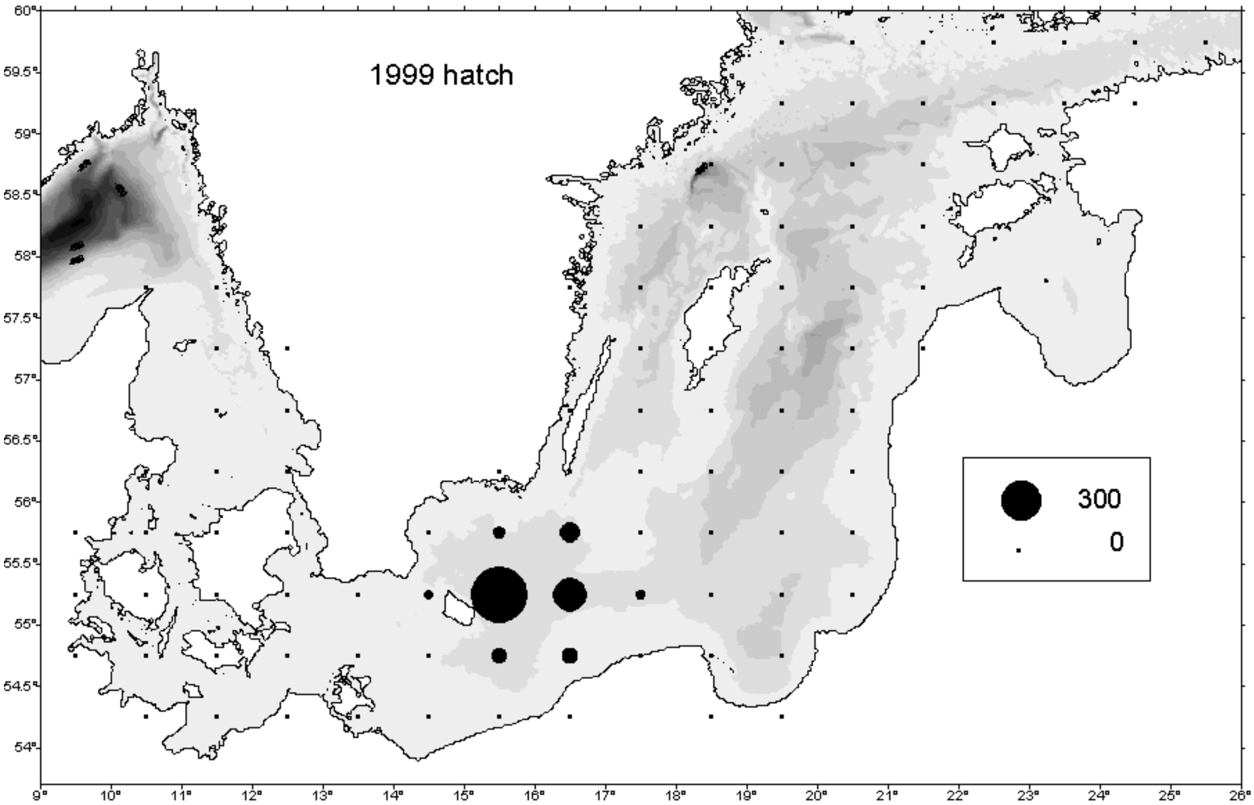


Fig. 4.18: Back-calculated hatching locations for sprat caught as larvae in May 1999.

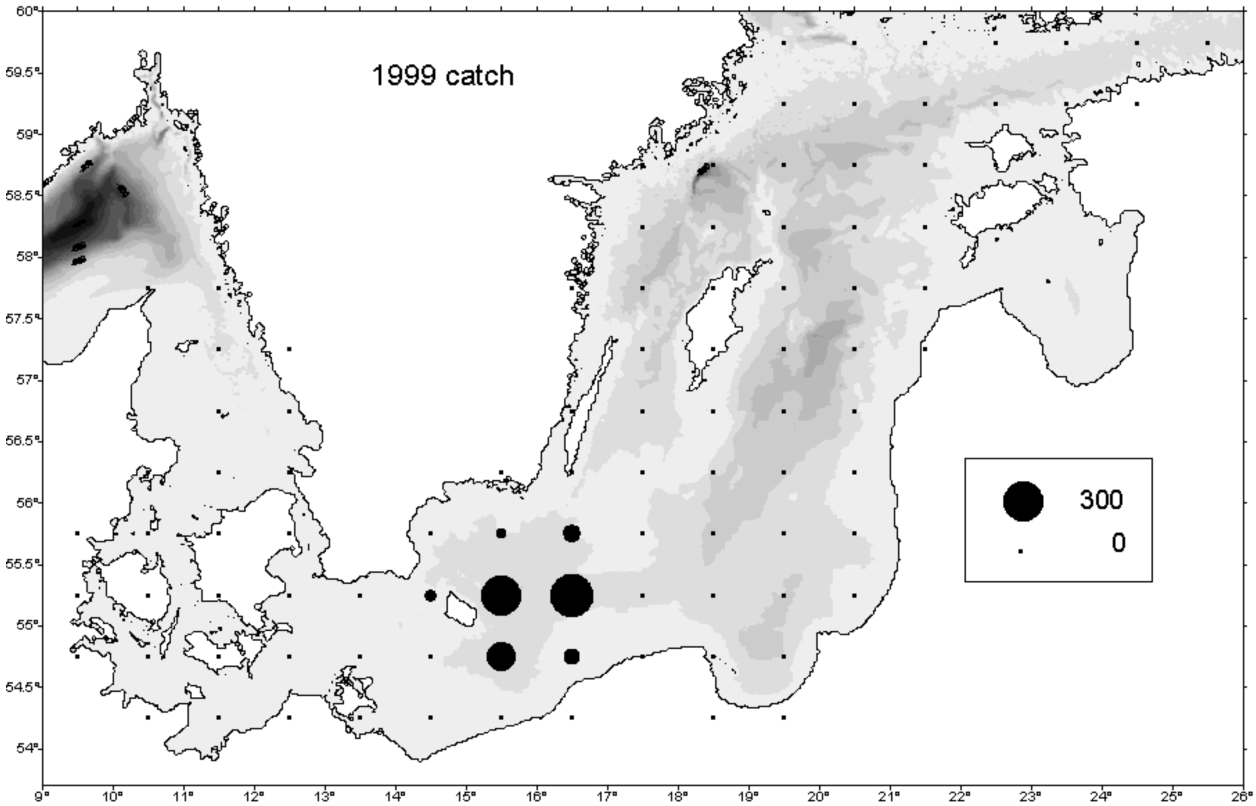


Fig. 4.19: Sprat larvae caught in May 1999.

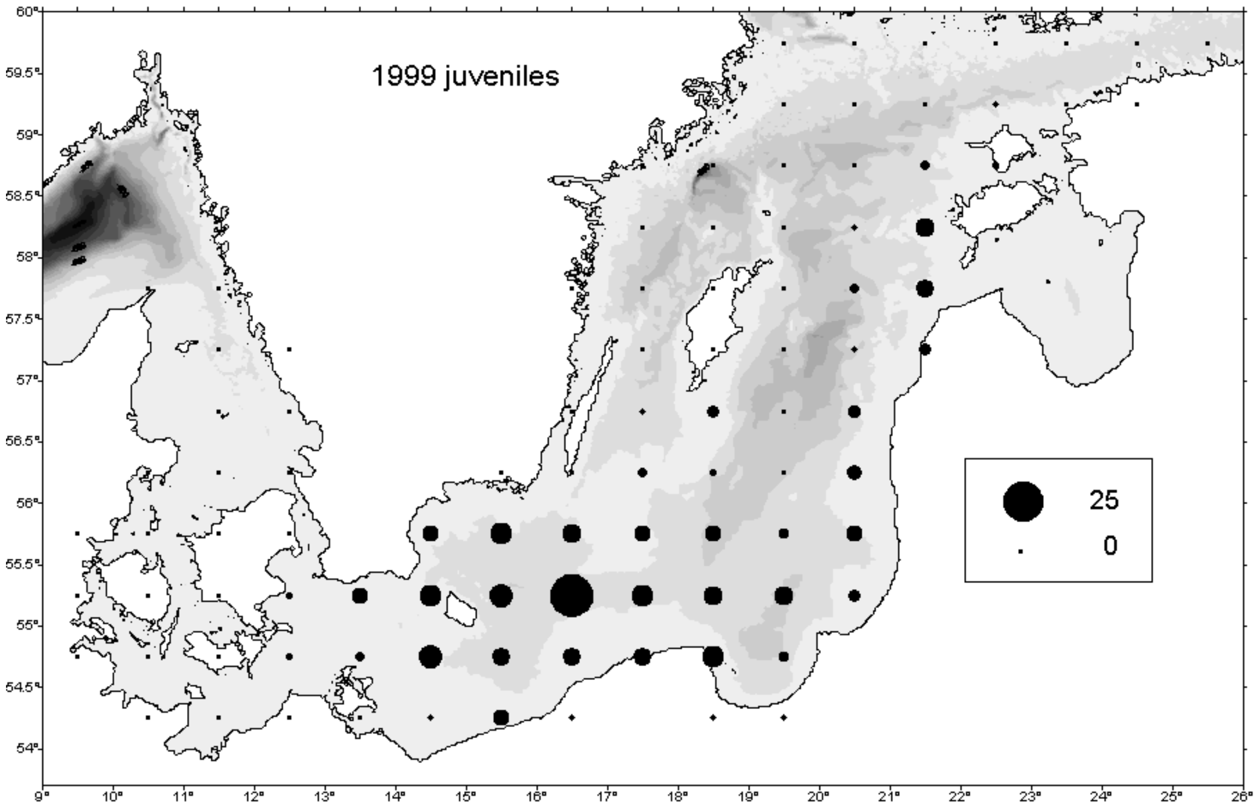


Fig. 4.20: Forward-calculated horizontal juvenile distribution of sprat in October 1999 caught as larvae in May 1999.

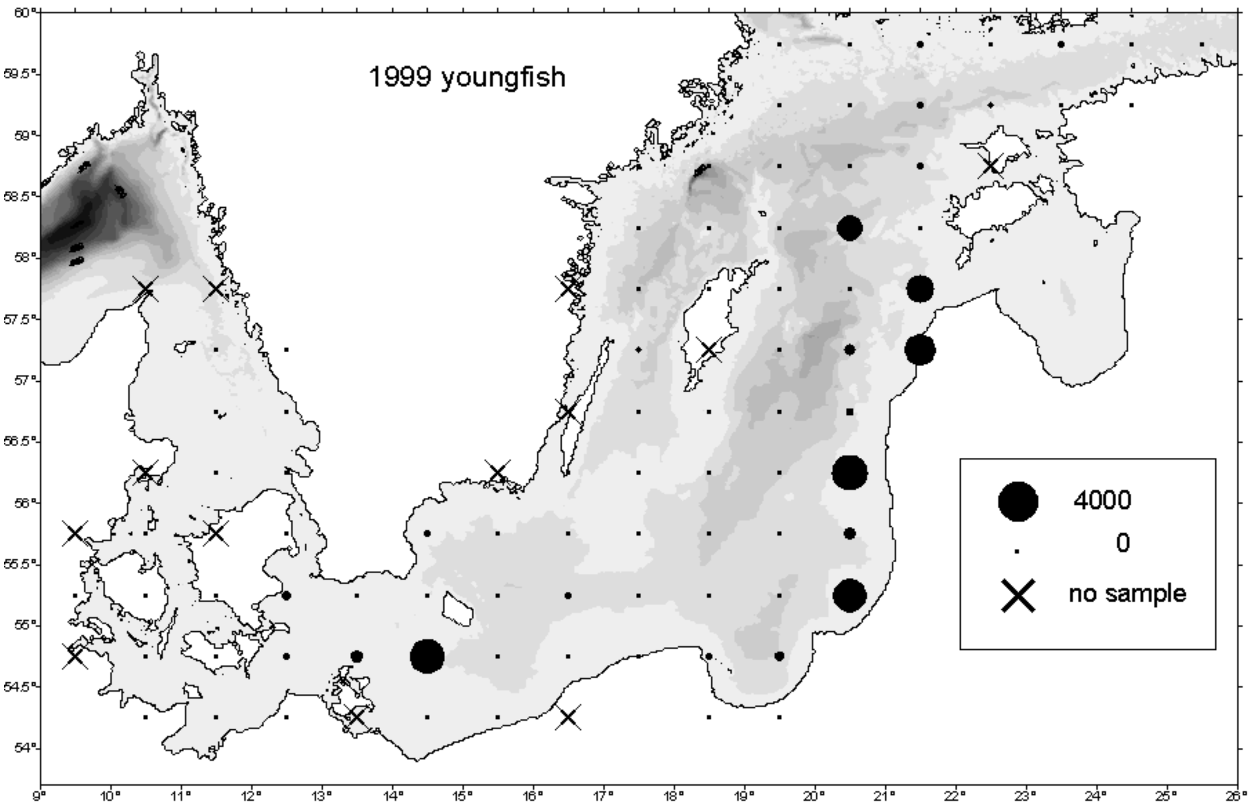


Fig. 4.21: Horizontal juvenile distribution of sprat obtained from hydroaccustics in October 1999

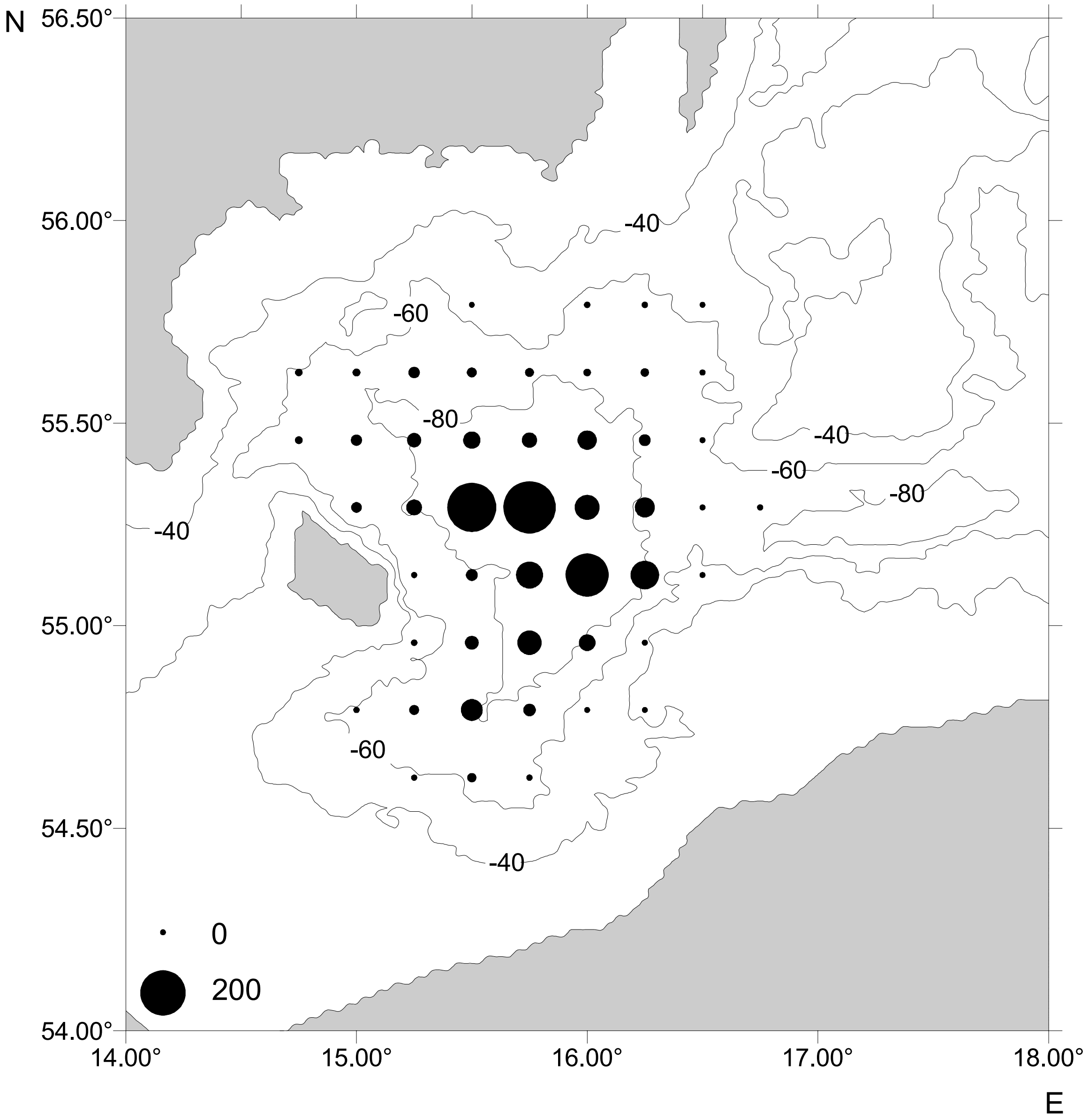


Fig. 4.22: Mean spatial egg distribution (number of eggs stage Ia) in the Bornholm Basin during main spawning time 1994-1996.

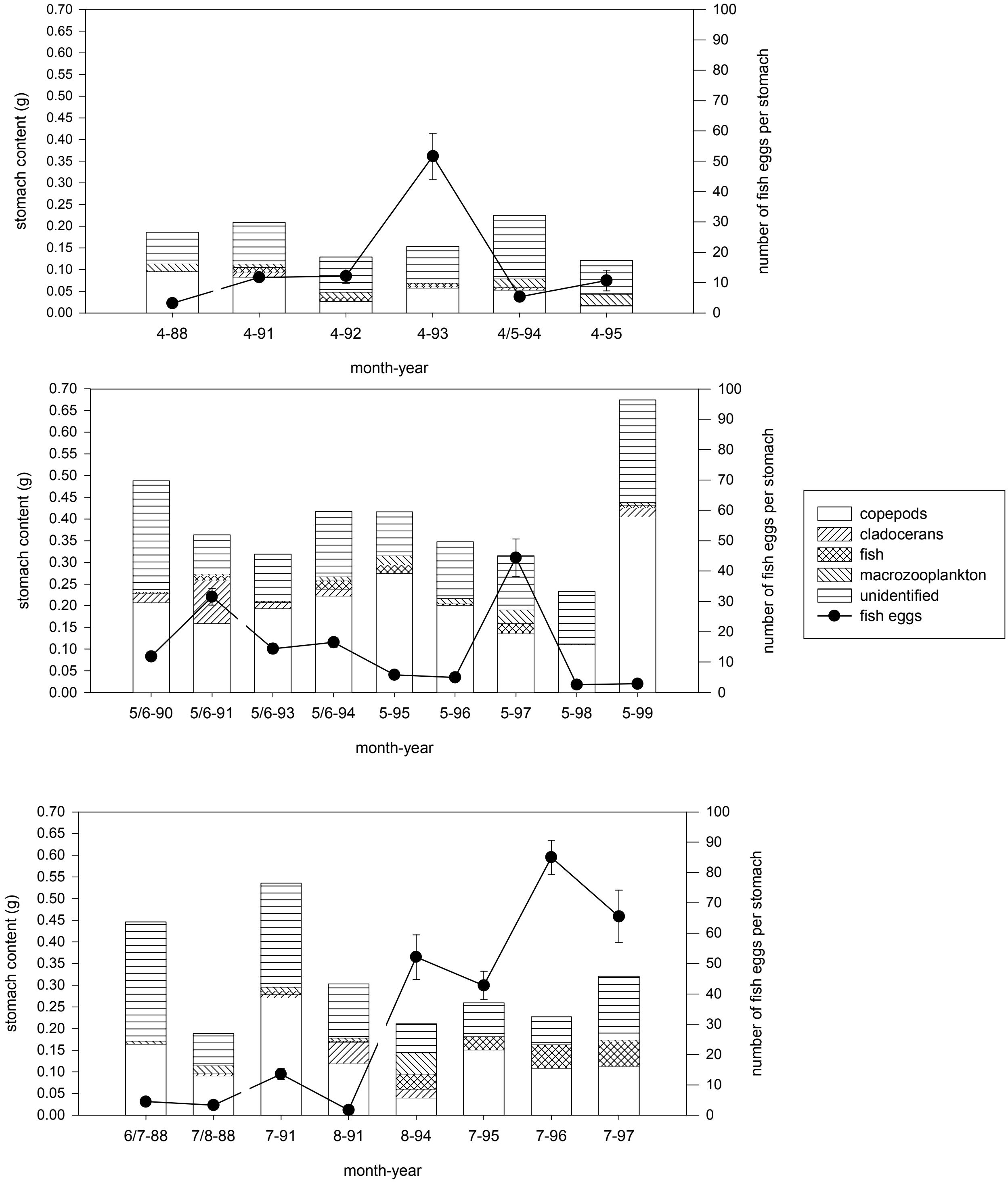


Fig. 5.1.1. Food composition of herring: *Average stomach content (in g wet weight) of major taxonomic prey groups and average number of fish eggs with corresponding standard error for different months of the cod spawning seasons 1988-99.*

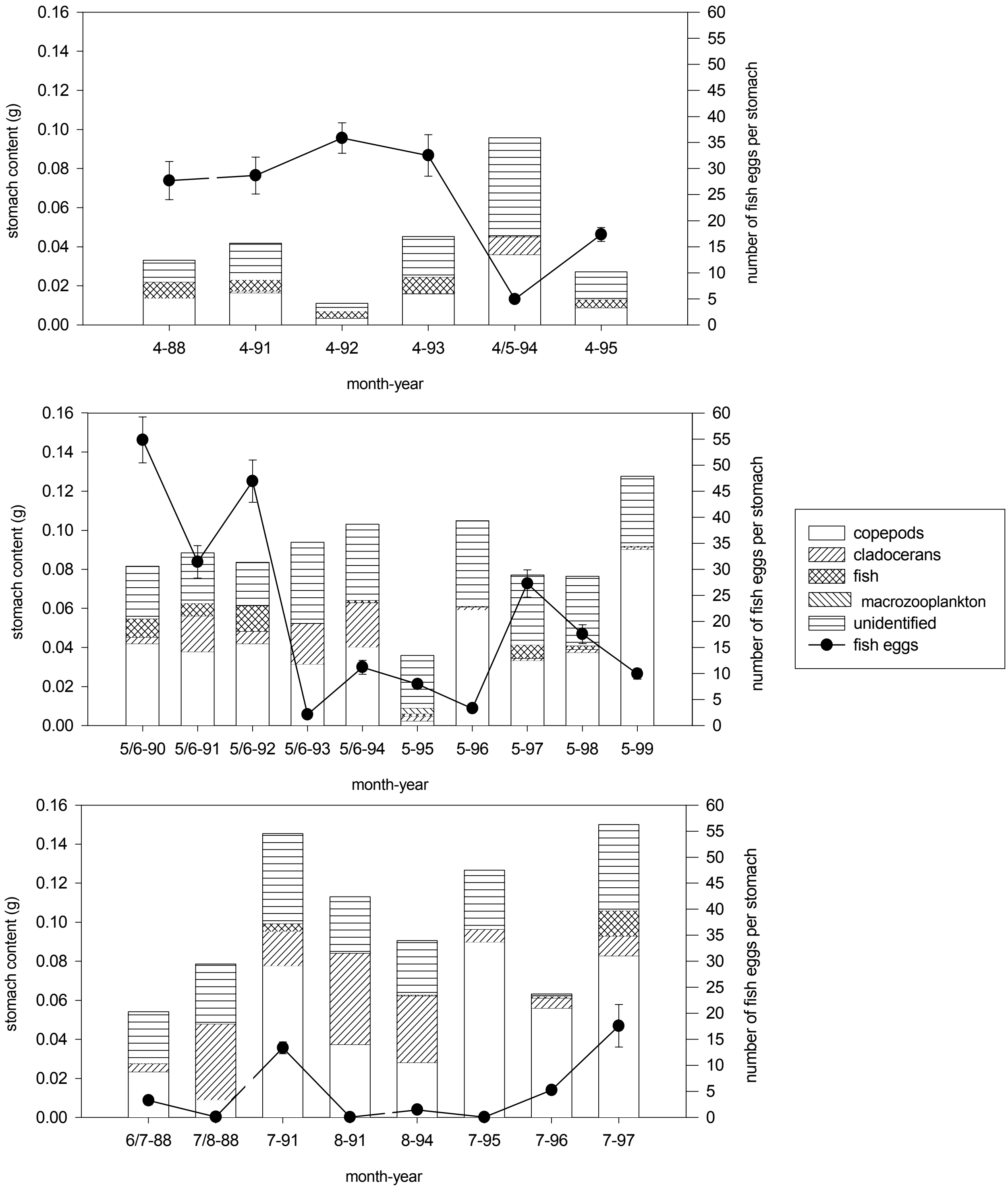


Fig. 5.1.2. Food composition of sprat: *Average stomach content (in g wet weight) of major taxonomic prey groups and average number of fish eggs with corresponding standard error for different months of the cod spawning seasons 1988-99.*

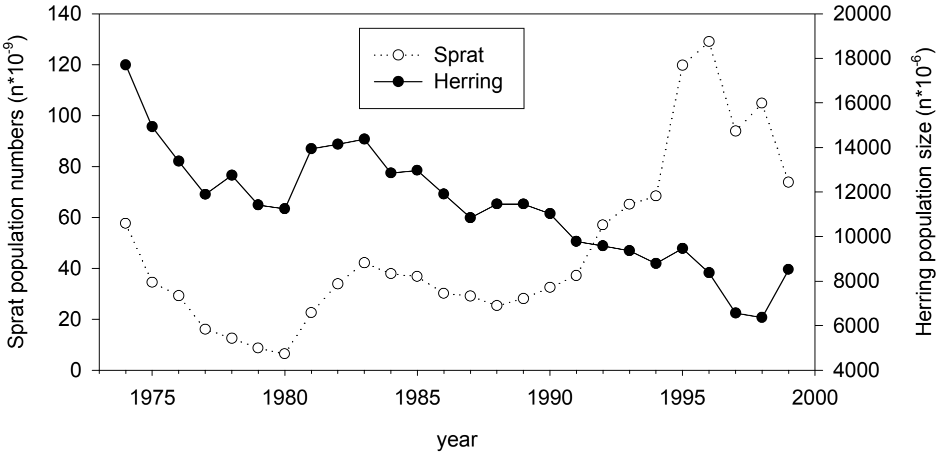


Fig. 5.1.3. Times-series of population size (age-groups 1+) of sprat and herring in Sub-division 25 from area-disaggregated MSVPA.

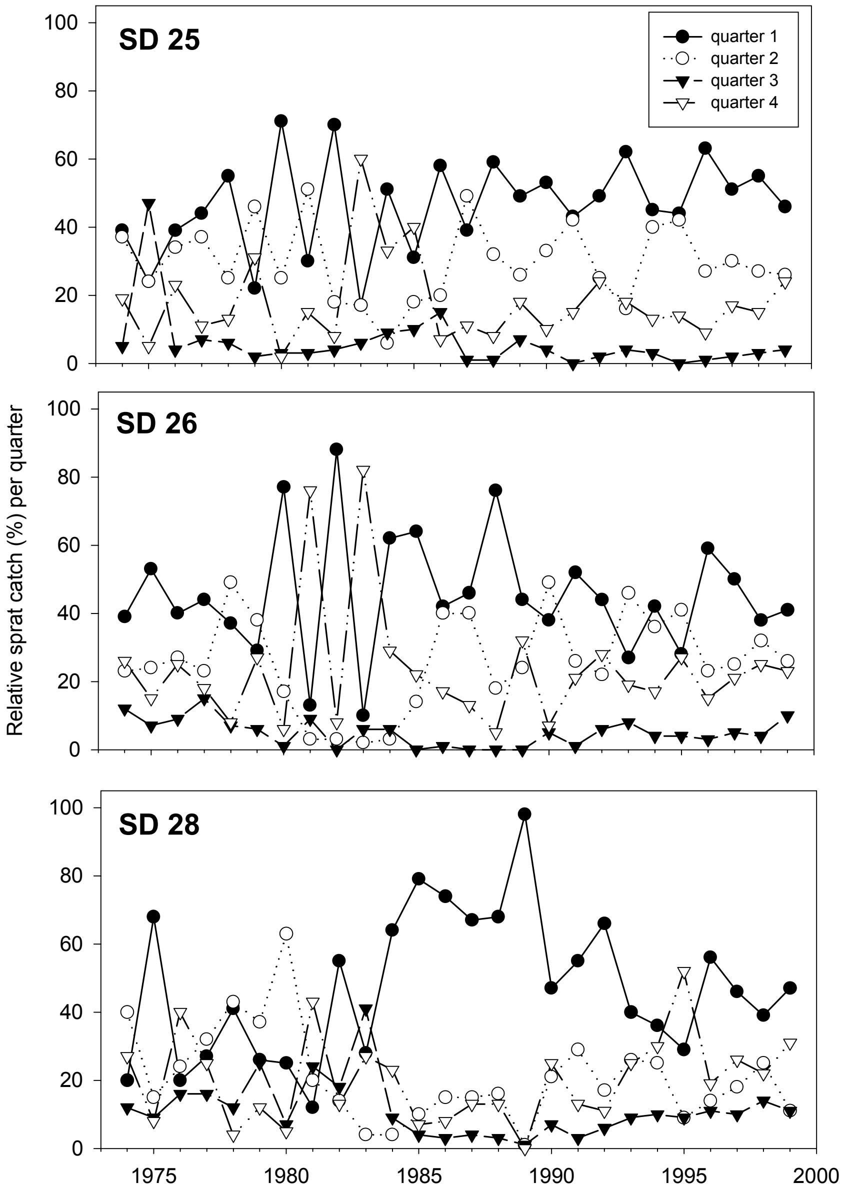


Fig. 5.1.4. Time-series of relative proportions of the annual sprat catch in Sub-divisions (SD) 25, 26 and 28 in the different quarters.

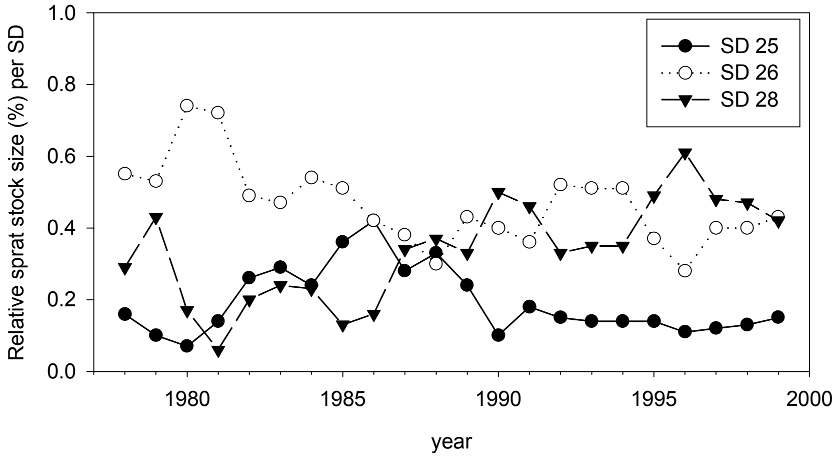


Fig. 5.1.5. Time-series of relative proportions of the sprat stock size in Sub-divisions (SD) 25, 26 and 28 derived from the International Hydroacoustic Survey in autumn.

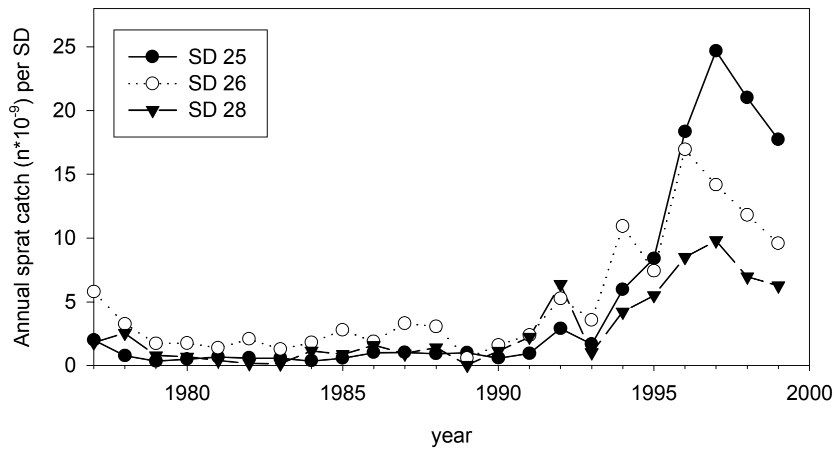
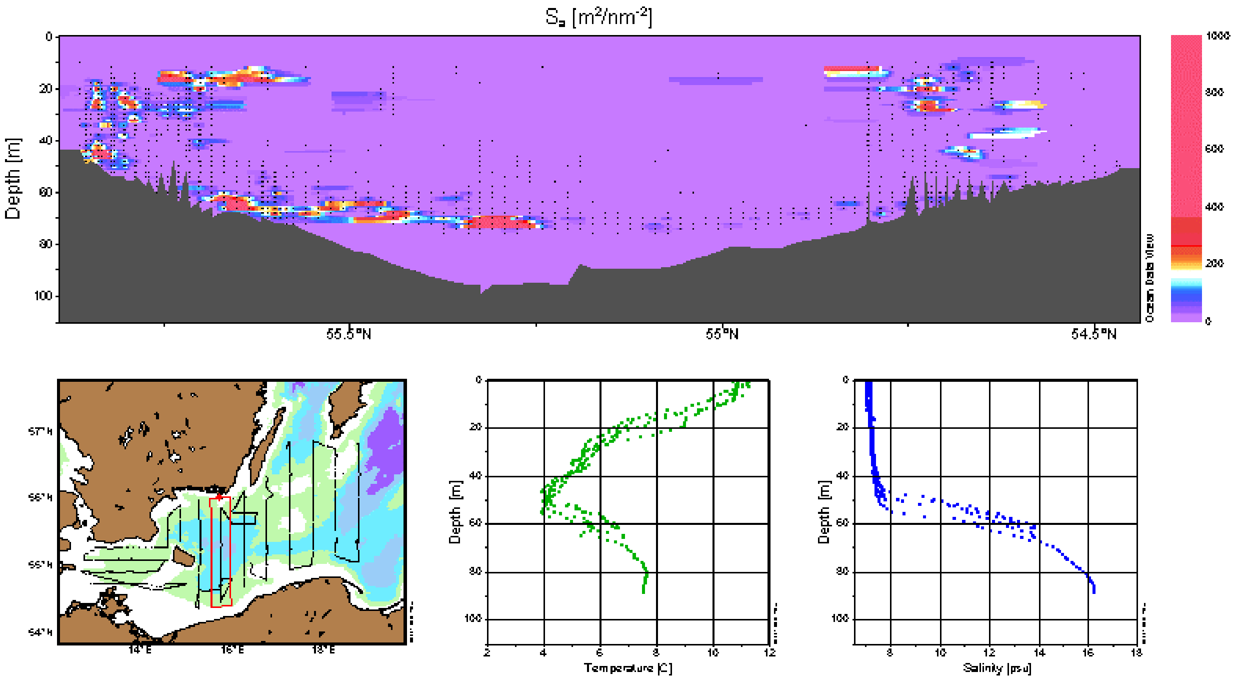


Fig. 5.1.6. Time-series of the annual sprat catch in Sub-divisions (SD) 25, 26 and 28.

a)



b)

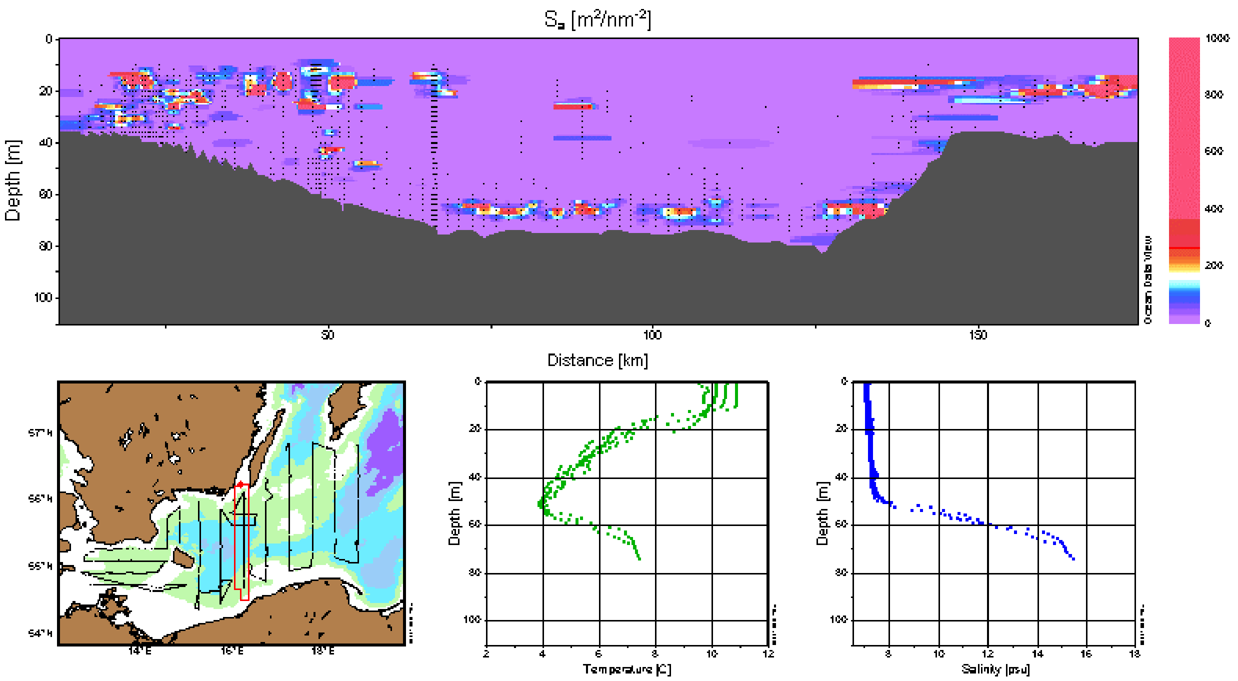


Fig. 5.1.7. Vertical distribution of sprat on transects along 15.7°E (a) and 16.2°E (b) [S_a-mean area scattering cross section] and lower panels giving transect position as well as respective vertical temperature and salinity profiles from the Bornholm Basin in May/June 1999.

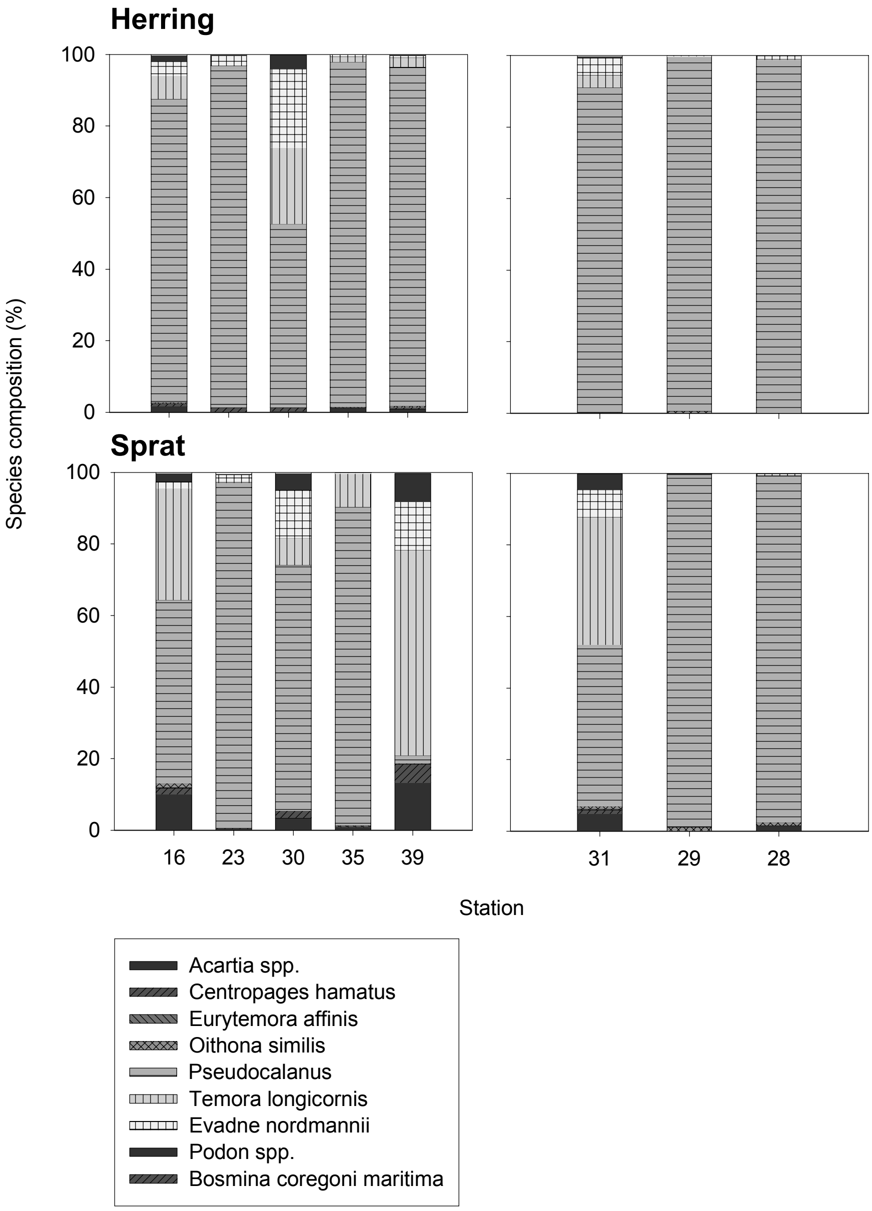


Fig. 5.1.8. Relative species composition in stomachs of herring and sprat sampled on different stations in the Bornholm Basin in May/June 1999.

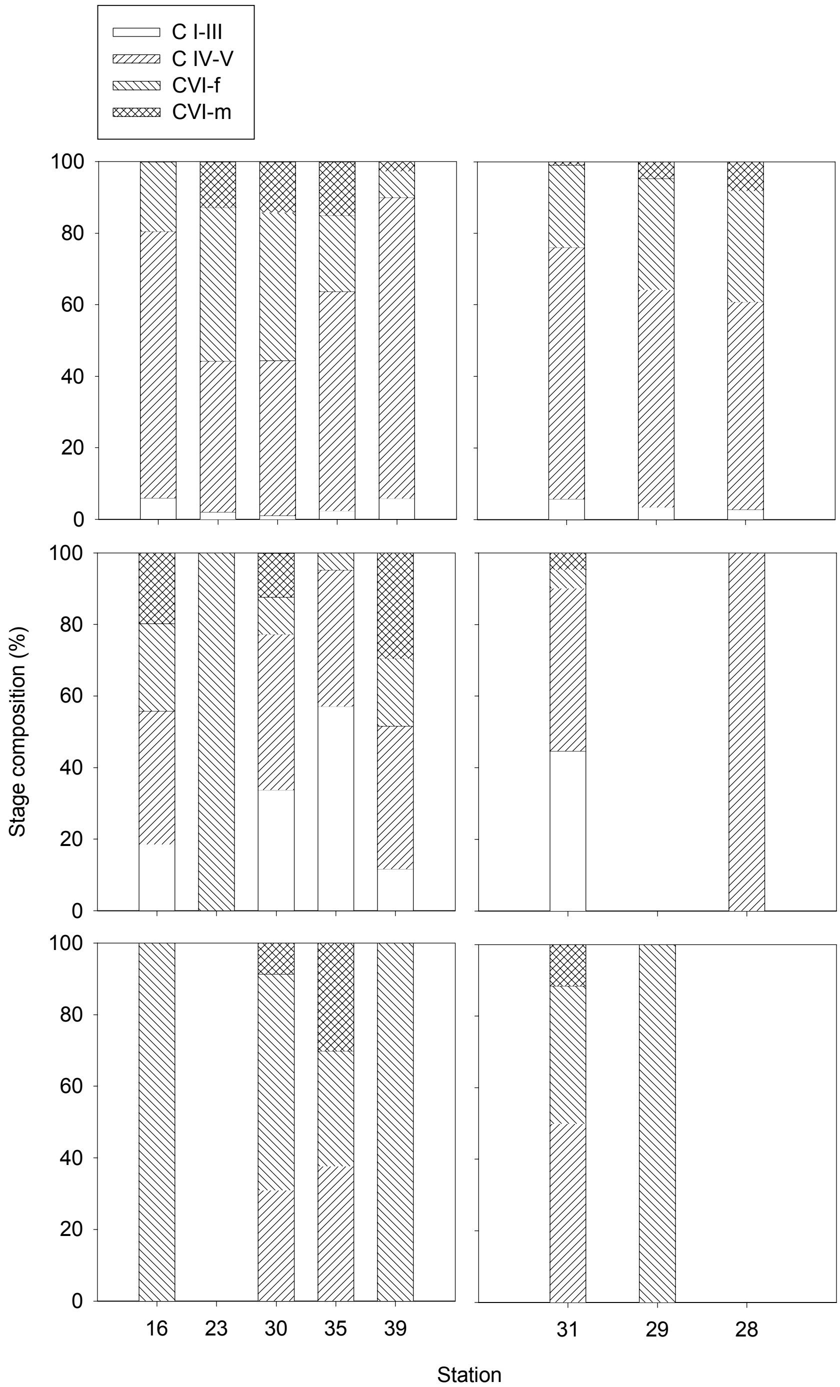


Fig. 5.1.9. Relative stage composition of *P. elongatus* (upper panels), *T. longicornis* (middle panels) and *Acartia* spp. (lower panels) in herring stomachs sampled on different stations in the Bornholm Basin in May/June 1999.

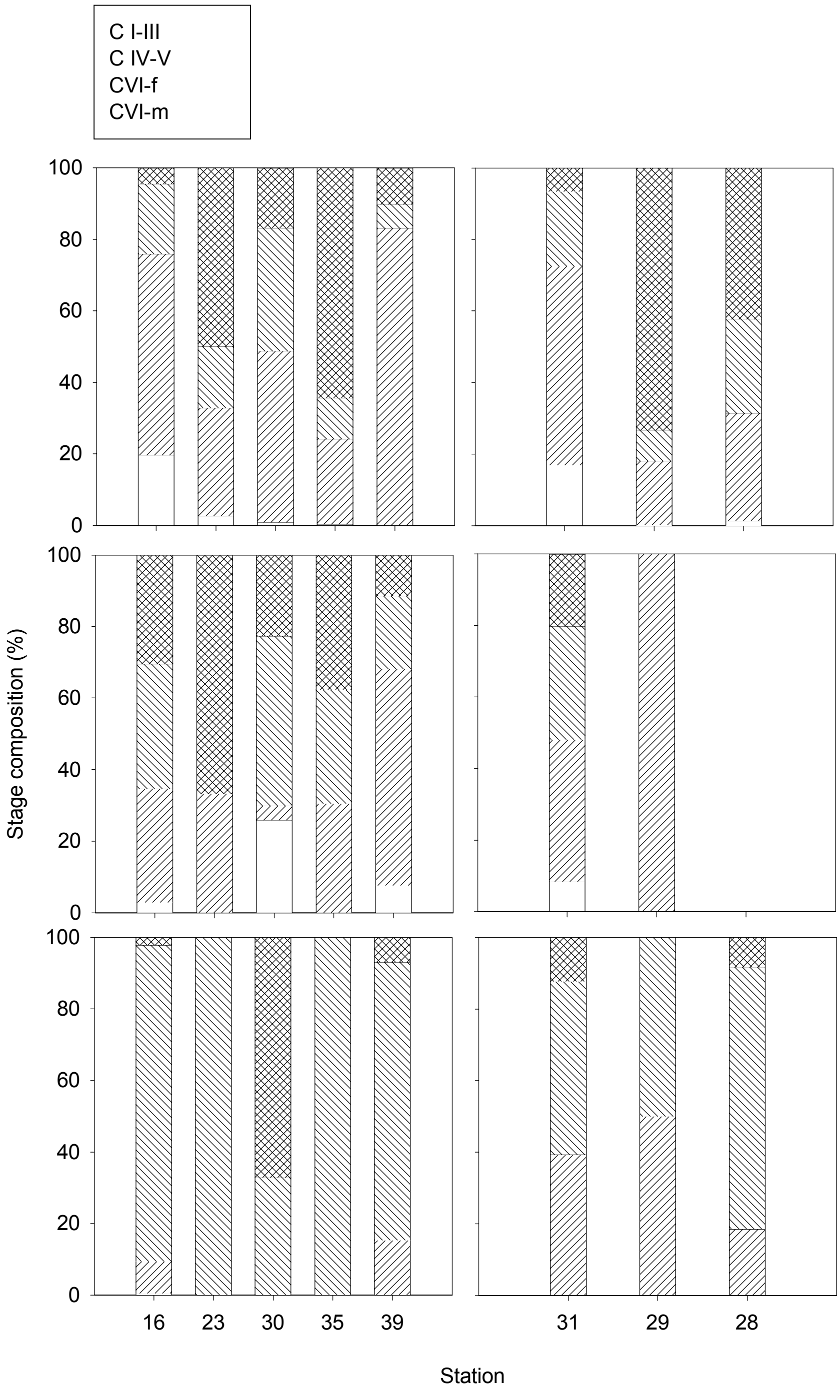


Fig. 5.1.10. Relative stage composition of *P. elongatus* (upper panels), *T. longicornis* (middle panels) and *Acartia* spp. (lower panels) in sprat stomachs sampled on different stations in the Bornholm Basin in May/June 1999.

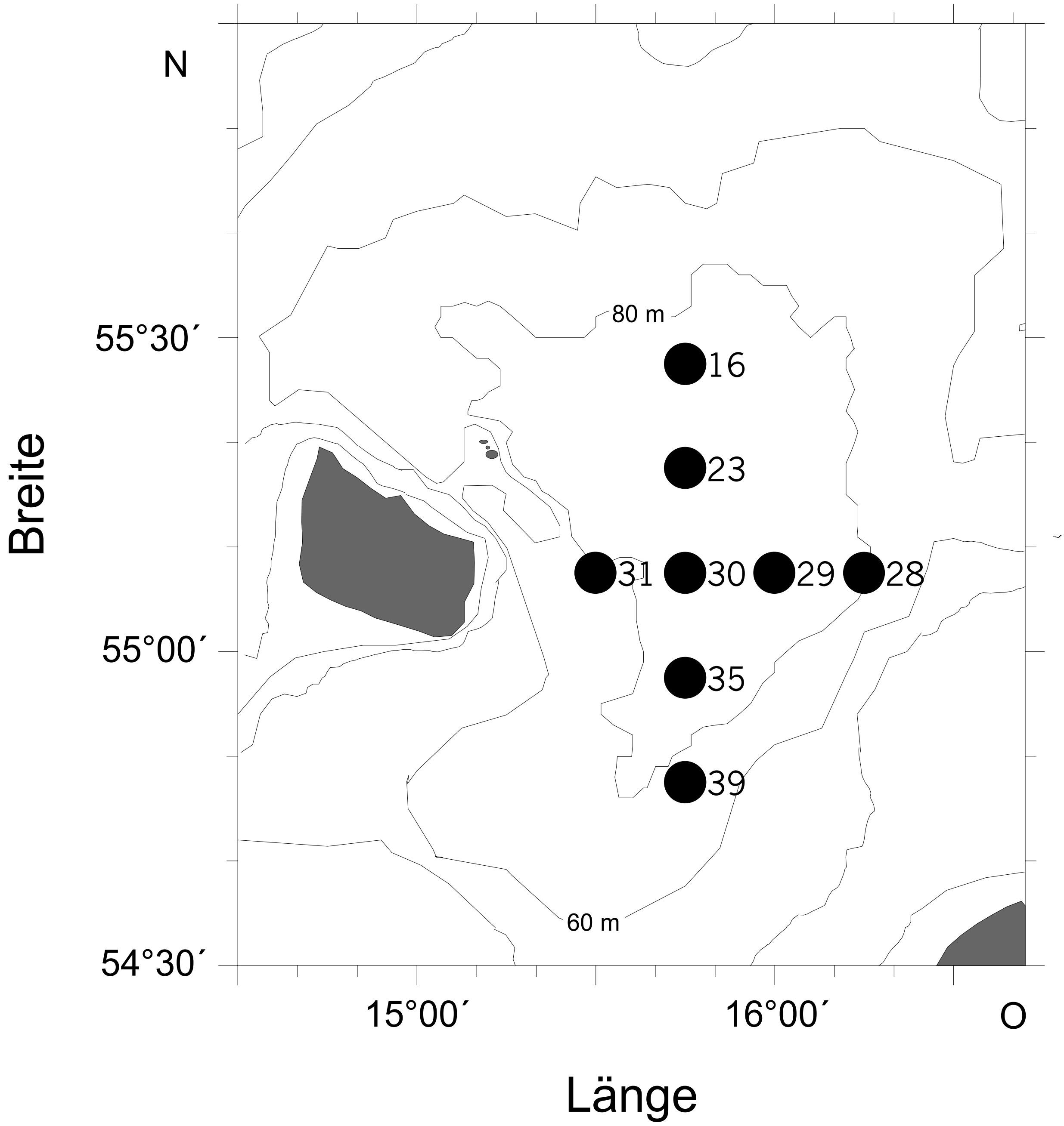


Fig. 5.1.11. Stations in the Bornholm Basin of which herring and sprat stomachs were sampled in May/June 1999 and analysed for the food selection study.

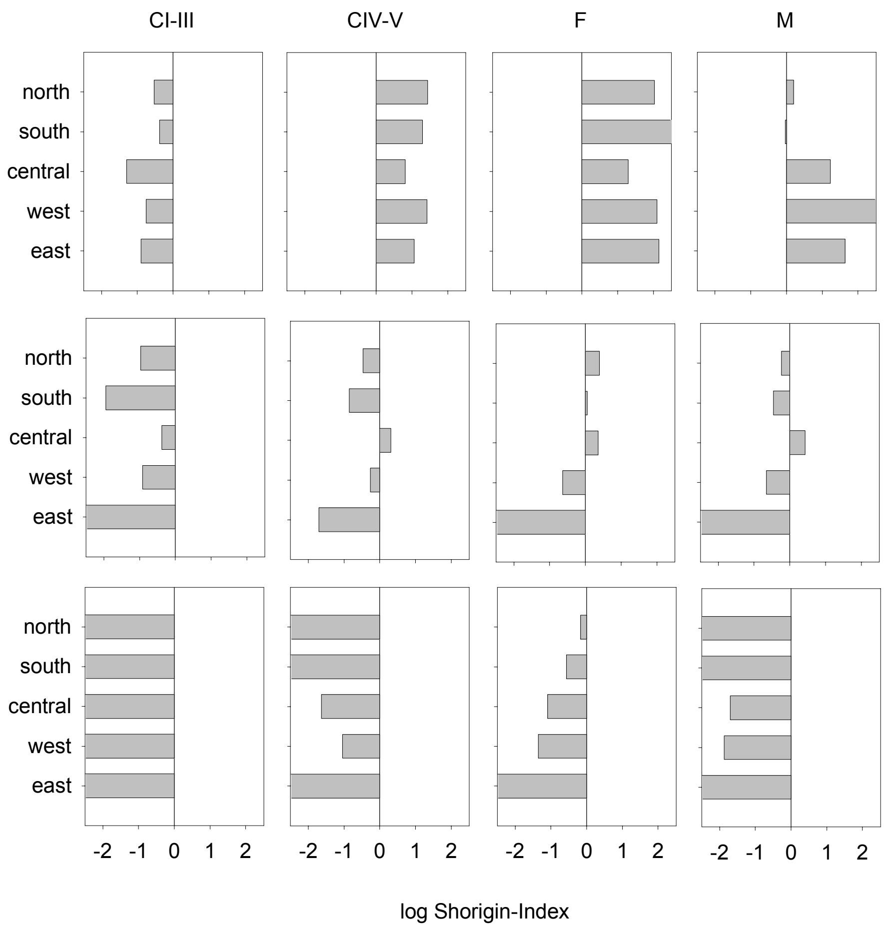


Fig. 5.1.12. Log-Shorigin-Indices for herring preying upon the different life-stages of *P. elongatus* (upper panels), *T. longicornis* (middle panels) and *Acartia* spp. (lower panels) on selected stations in the Bornholm Basin in May/June 1999.

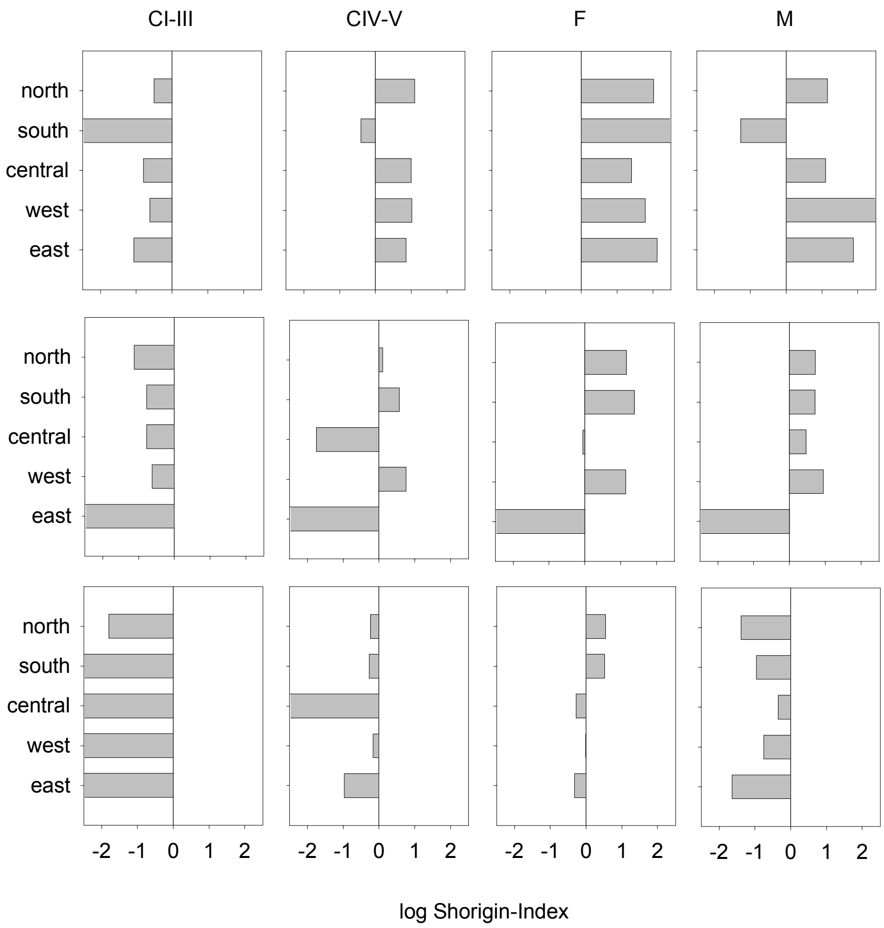


Fig. 5.1.13. Log-Shorigin-Indices for sprat preying upon the different life-stages of *P. elongatus* (upper panels), *T. longicornis* (middle panels) and *Acartia* spp. (lower panels) on selected stations in the Bornholm Basin in May/June 1999.

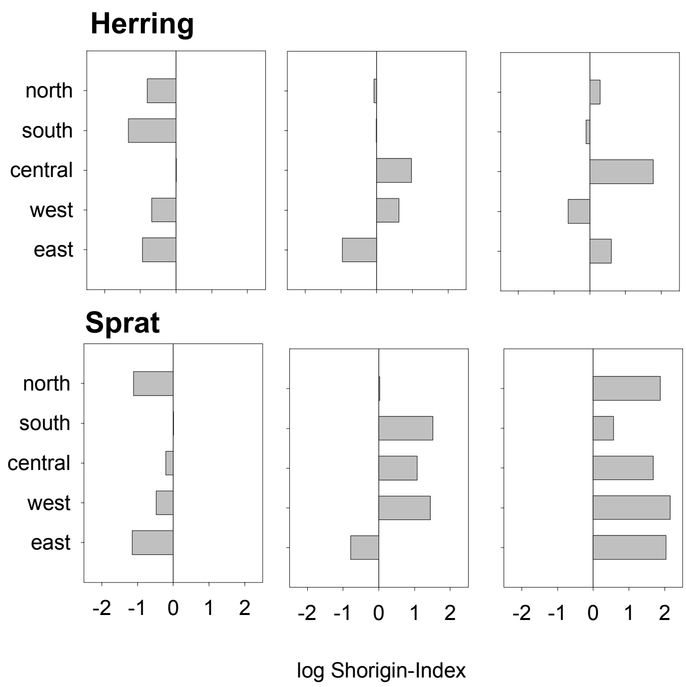


Fig. 5.1.14. Log-Shorigin-Indices for herring and sprat preying upon *E. nordmannii* (left column), *Podon* spp. (middle column) and fish eggs (right column) on selected stations in the Bornholm Basin in May/June 1999.

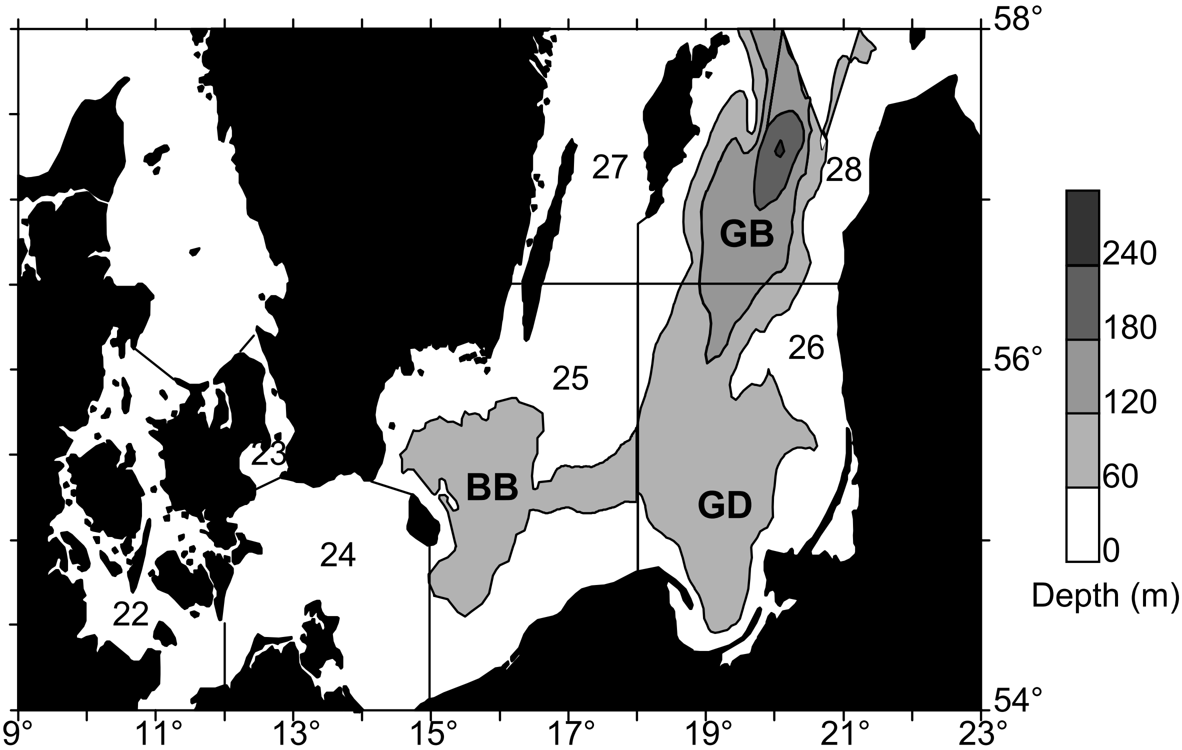


Fig. 5.1.15. Spawning araes of sprat and cod in the Central Baltic Sea. BB-Bornholm Basin; GD-Gdansk Deep; GB-Gotland Basin.

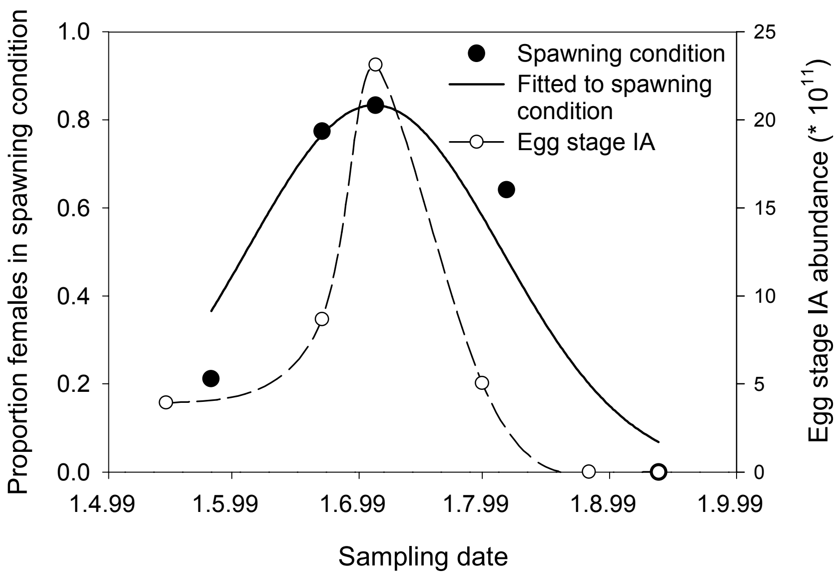


Fig. 5.1.16. Average proportions of mature females in spawning condition (three parameter Gaussian curve fit) and corresponding egg abundance of the youngest egg stage IA per sampling date in 1999.

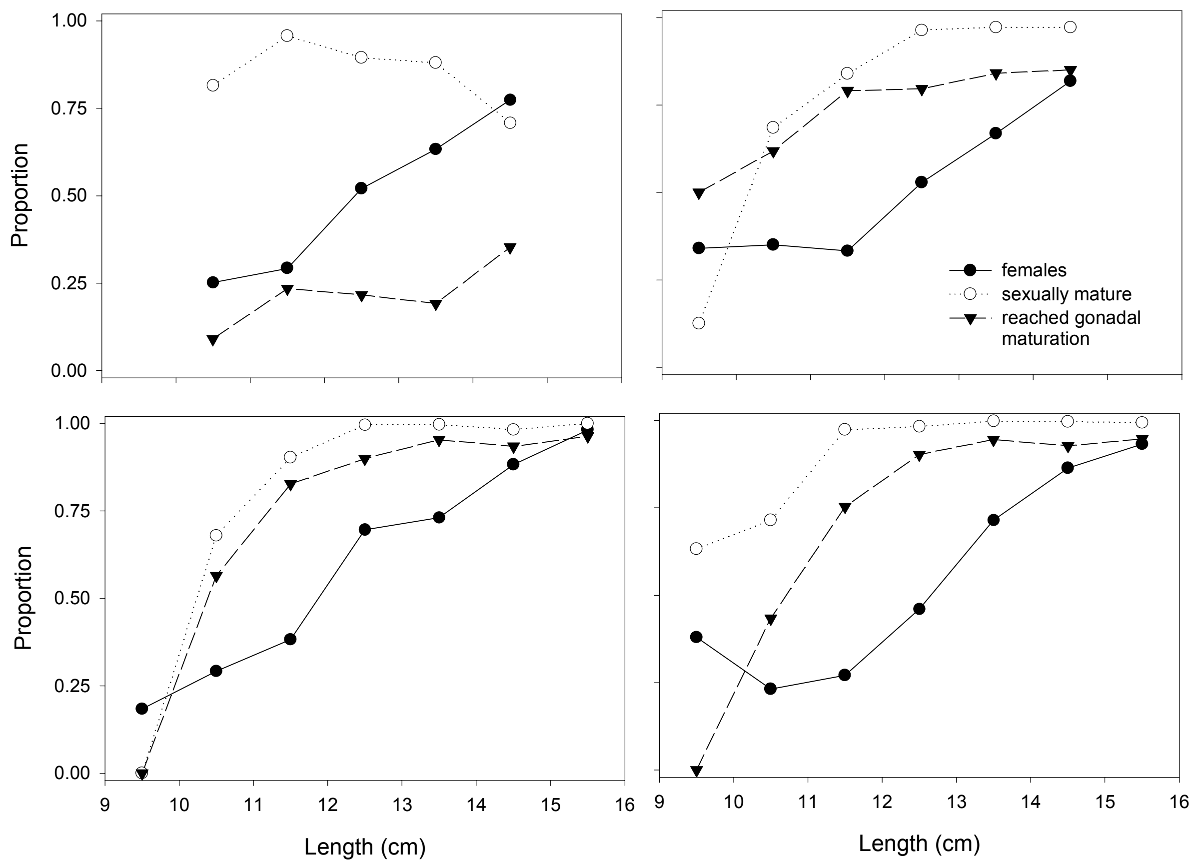


Fig. 5.1.17. Proportion of females, sexually mature females and females having reached gonadal maturity, i.e. entered the spawning cycle (calculated as proportion from sexually mature sprat), according to length in the sprat population of Sub-division 25 in April (a), May (b), June (c) and July (d) 1999.

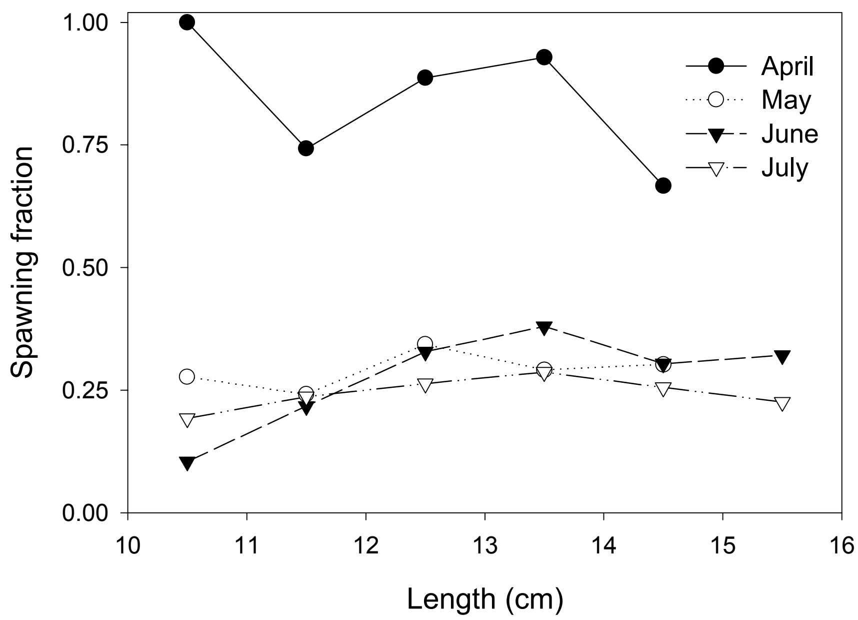


Fig. 5.1.18. Fraction of females in actual spawning condition from females having reached gonadal maturation according to length at different months of the 1999 spawning season.

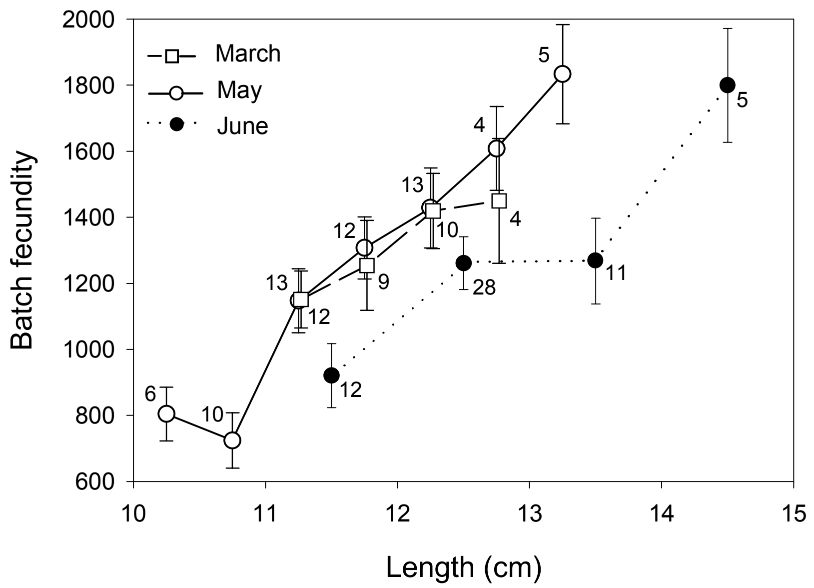


Fig. 5.1.19. Average number of eggs released per female per spawning event according to length with standard error in March and May (Feldman unpubl.) and own investigations in June 1999; numbers represent the analysed ovaries.

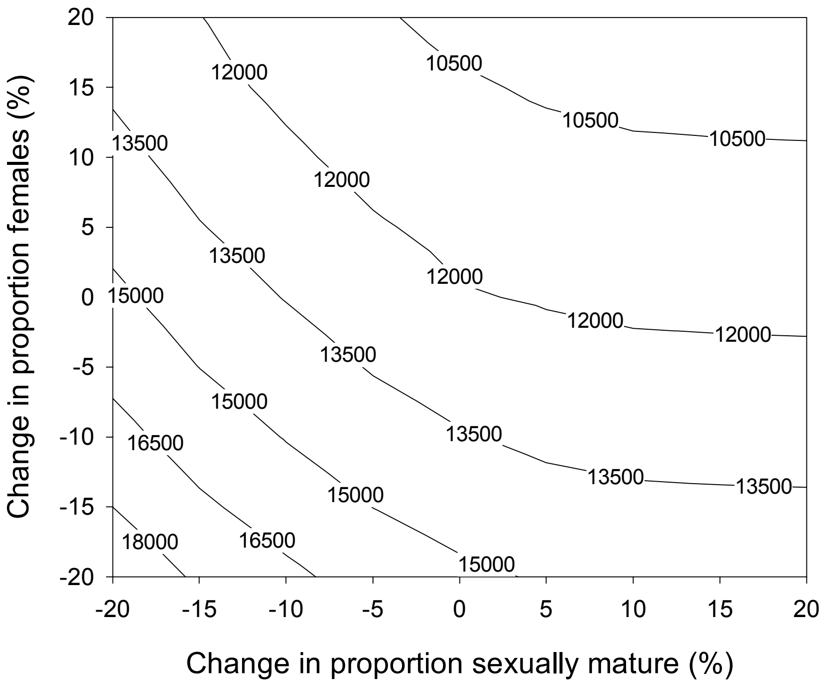


Fig. 5.1.20. Estimates of sprat population size in the Bornholm Basin (in millions) from daily egg production method varying the average proportion of females in the population and the proportion of females being sexually mature in each length-class by –20 to +20%.

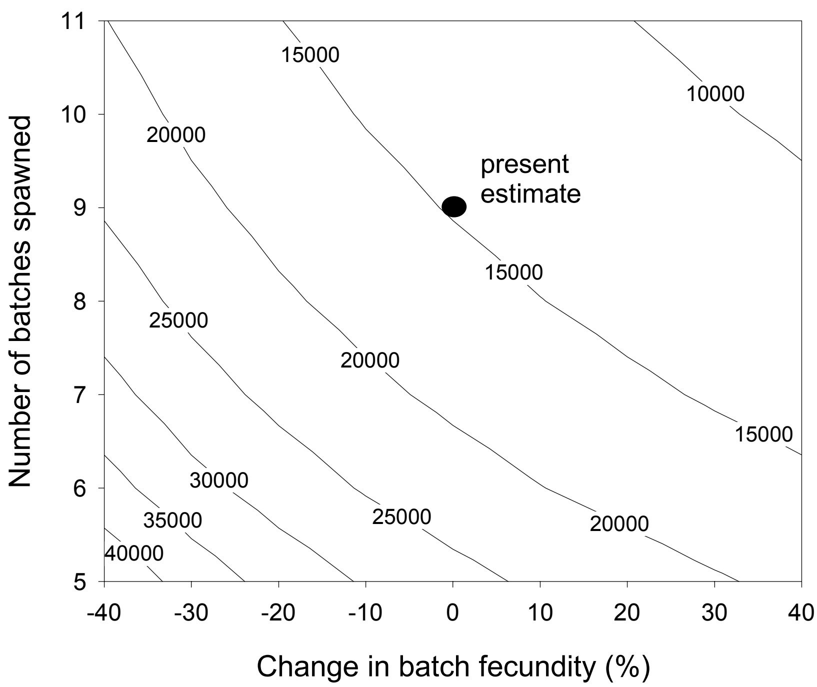


Fig. 5.1.21. Estimates of sprat population size in Sub-division 25 (in millions) from seasonal egg production varying the average batch fecundity by –40 to +40% and varying the number of batches spawned by an individual female from 5 to 11.

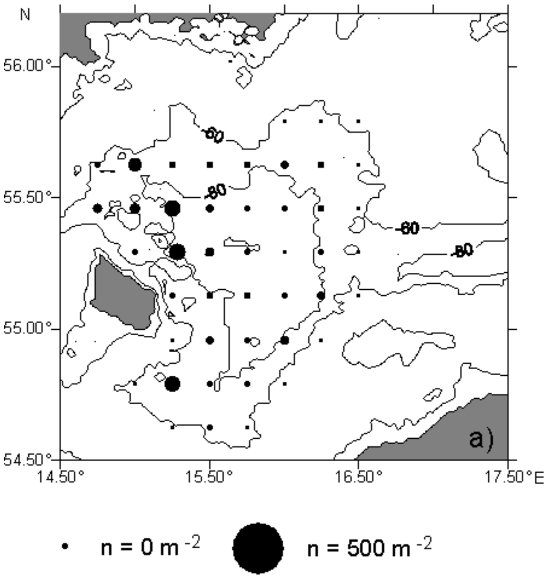


Fig. 5.1.22. Sprat egg distribution (stage IA) in the Bornholm Basin in early June 1999.

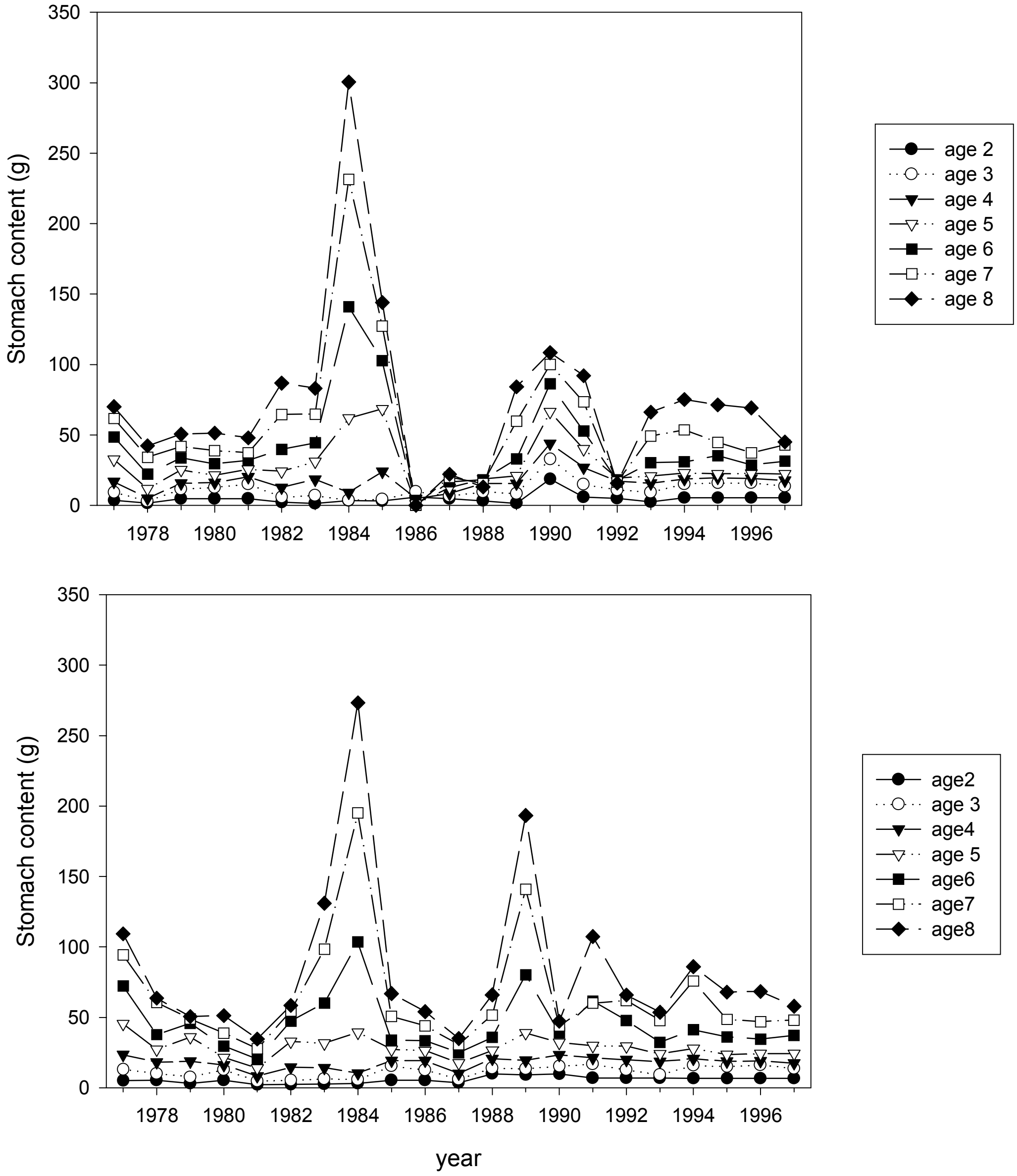


Fig. 5.2.1a. Development of average of cod stomach contents of age-groups 2 to 8 in the 1st(above) and 2nd Quarter (below) of years 1977 to 1997 in Subdivision 25.

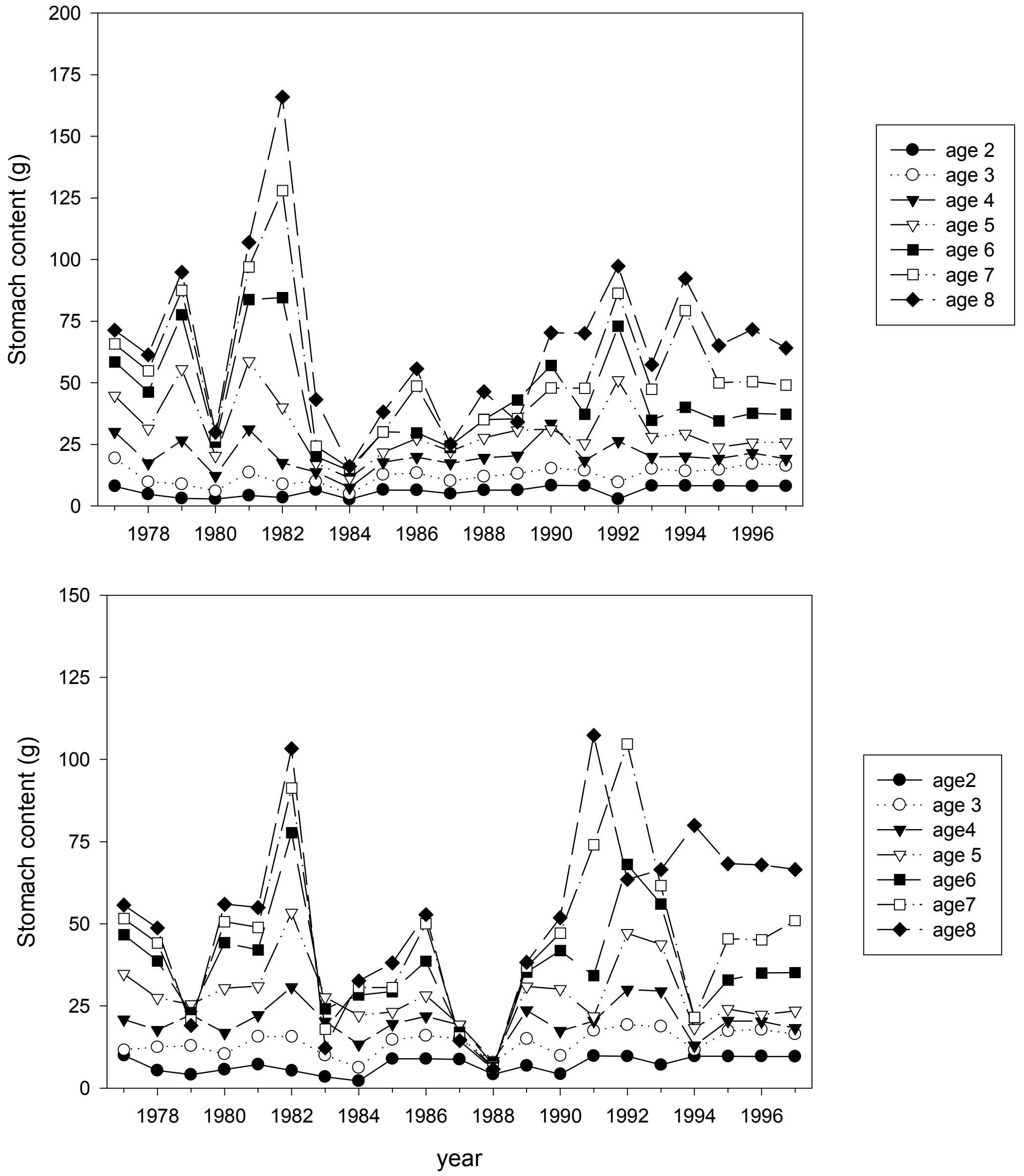
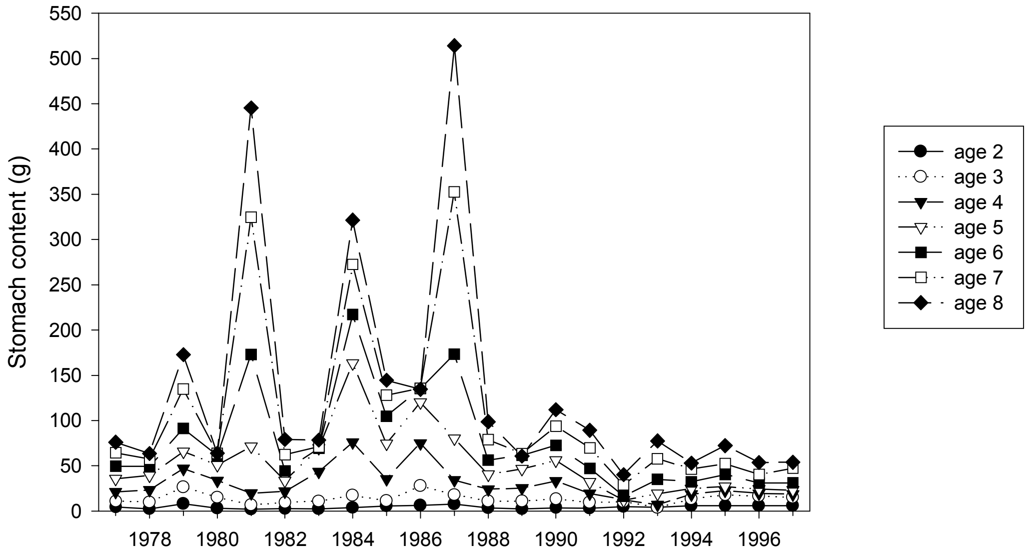


Fig. 5.2.1b. Development of average cod stomach contents of age-groups 2 to 8 in the 3rd (above) and 4th Quarter (below) of years 1977 to 1997 in Subdivision 25.



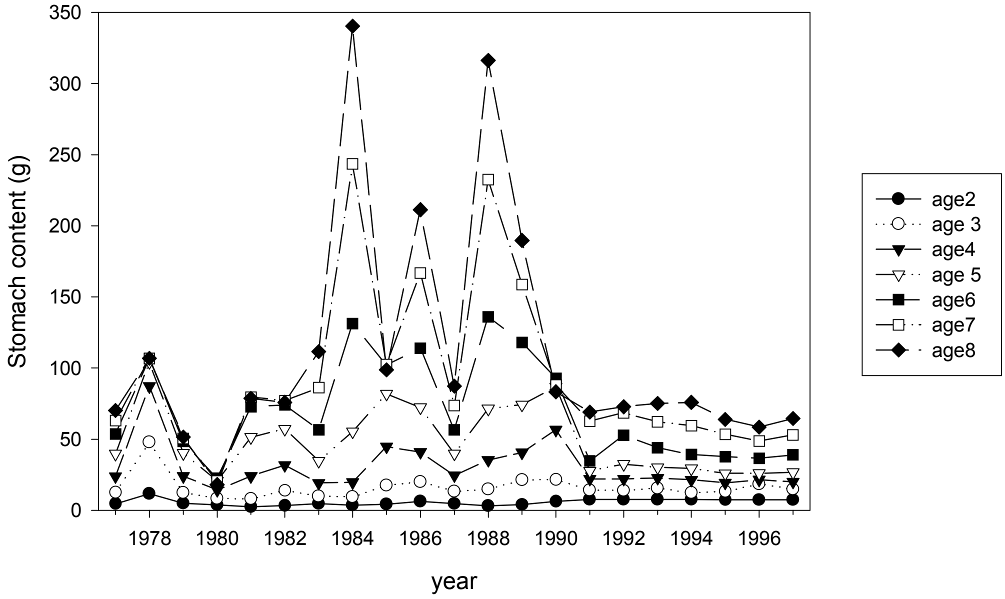
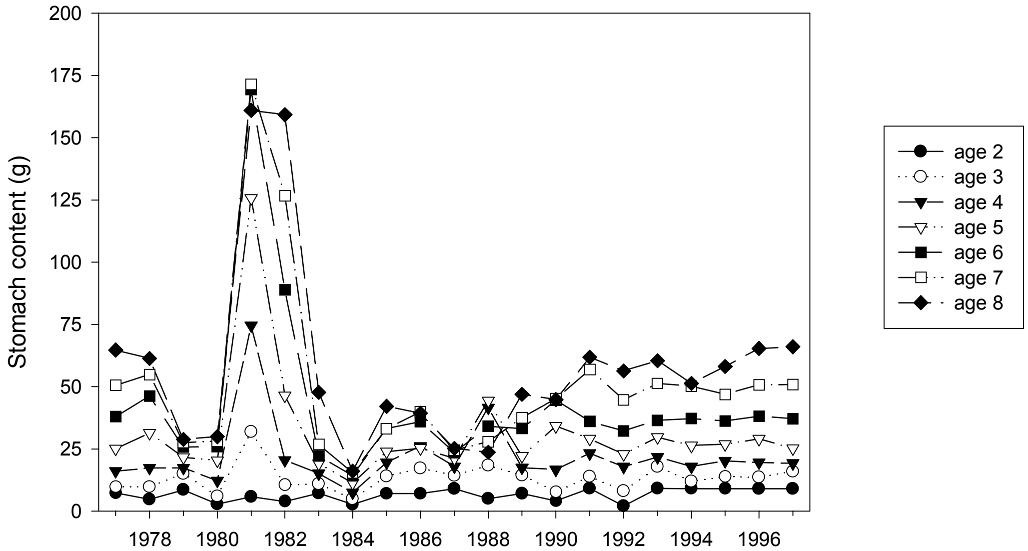


Fig. 5.2.2a. Development of average cod stomach contents of age-groups 2 to 8 in the 1st(above) and 2nd Quarter (below) of years 1977 to 1997 in Subdivision 26.



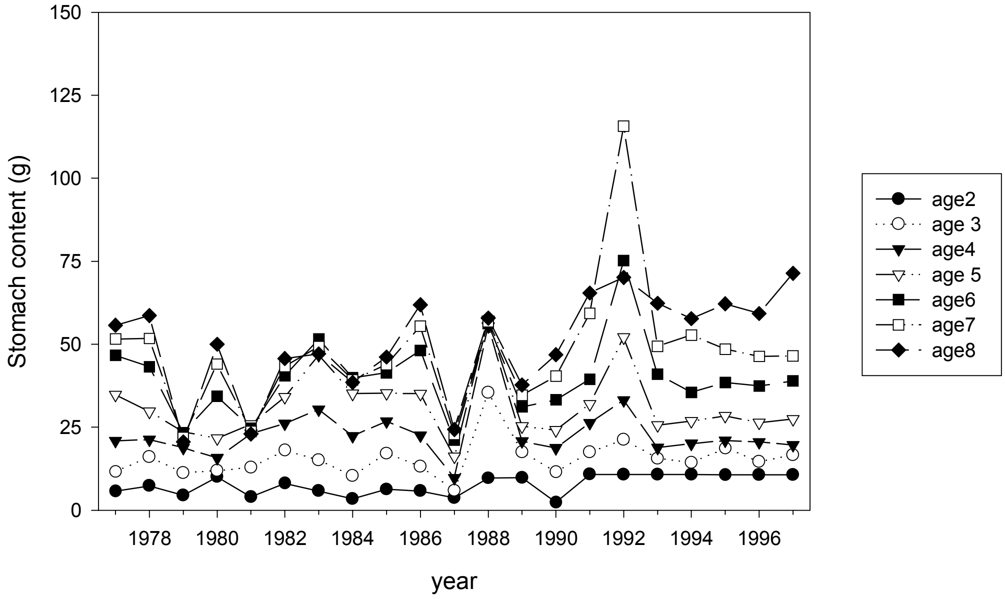


Fig. 5.2.2b. Development of average cod stomach contents of age-groups 2 to 8 in the 3rd (above) and 4th Quarter (below) of years 1977 to 1997 in Subdivision 26.

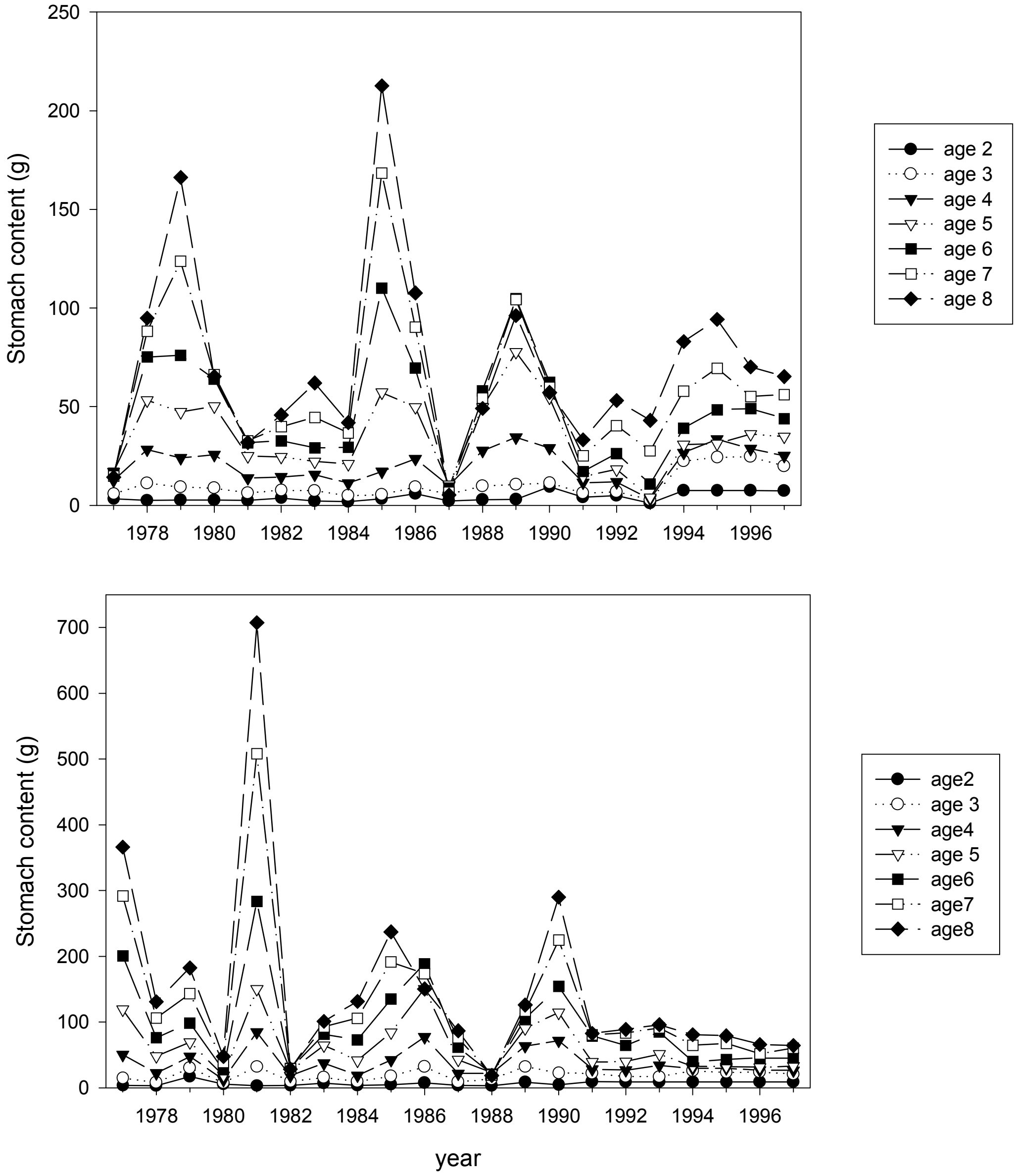


Fig. 5.2.3a. Development of average cod stomach contents of age-groups 2 to 8 in the 1st (above) and 2nd Quarter (below) of years 1977 to 1997 in Subdivision 28.

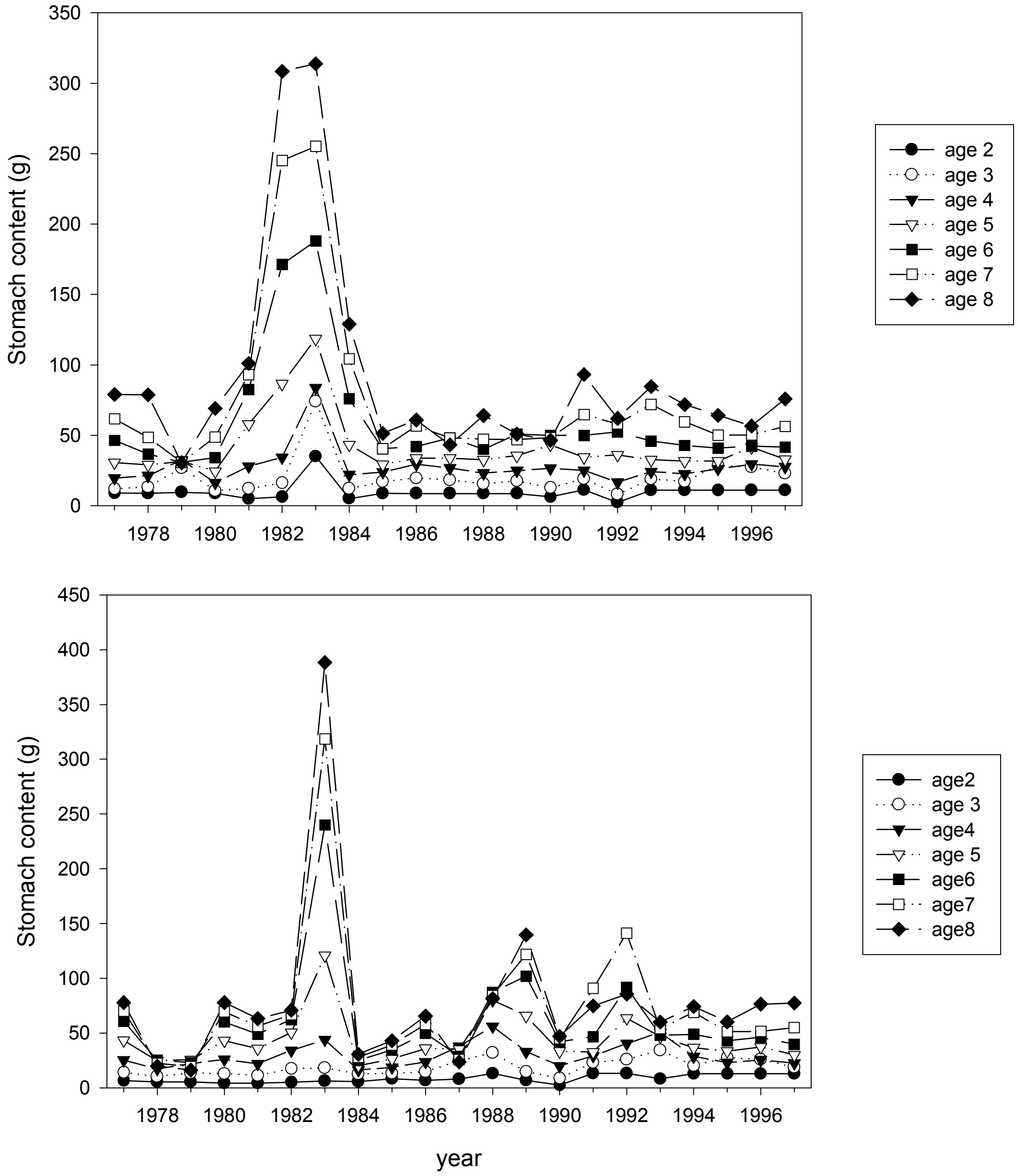


Fig. 5.2.3b. Development of average cod stomach contents of age-groups 2 to 8 in the 3rd (above) and 4th Quarter (below) of years 1977 to 1997 in Subdivision 28.

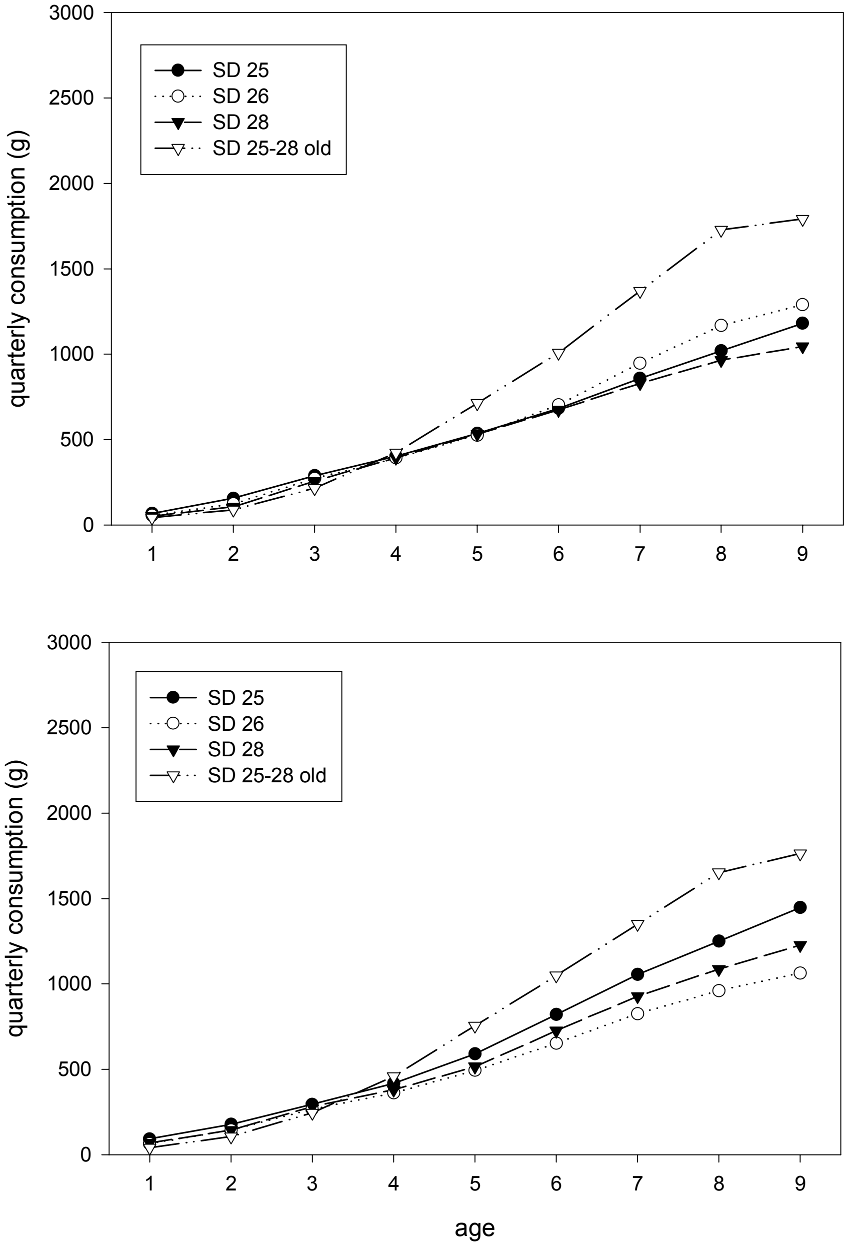
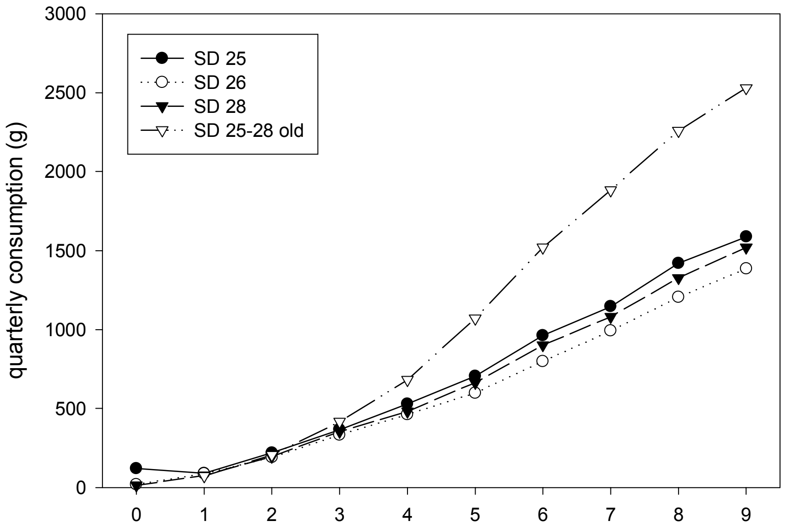


Fig. 5.2.4a. Comparison of individual cod consumption rates (averages over years 1977-1997) for the 1st (above) and the 2nd (below) quarter estimated with the new model, incorporating actual ambient temperatures and predator weight, in Subdivisions 25, 26 & 28 with corresponding estimates derived with the old model for combined Subdivisions 25-28.



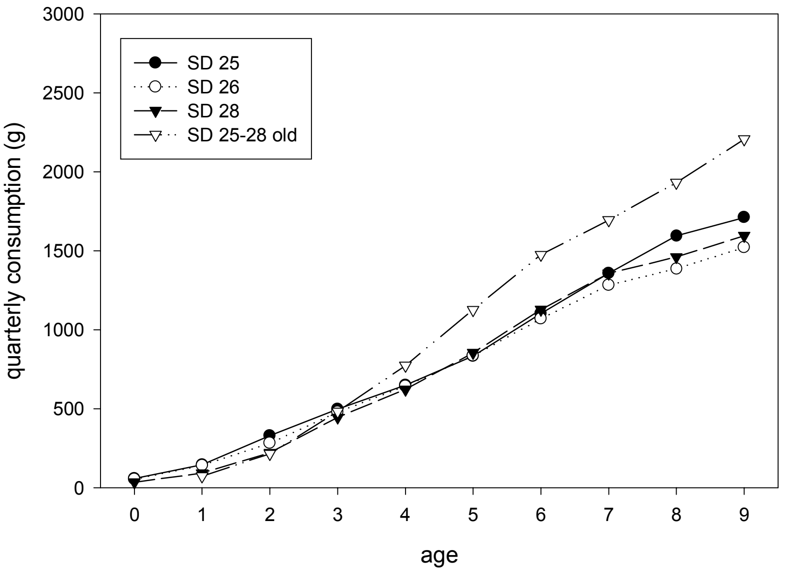


Fig. 5.2.4b. Comparison of individual cod consumption rates (averages over years 1977-1997) for the 3rd (above) and the 4th (below) quarter estimated with the new model, incorporating actual ambient temperatures and predator weight, in Subdivisions 25, 26 & 28 with corresponding estimates derived with the old model for combined Subdivisions 25-28.

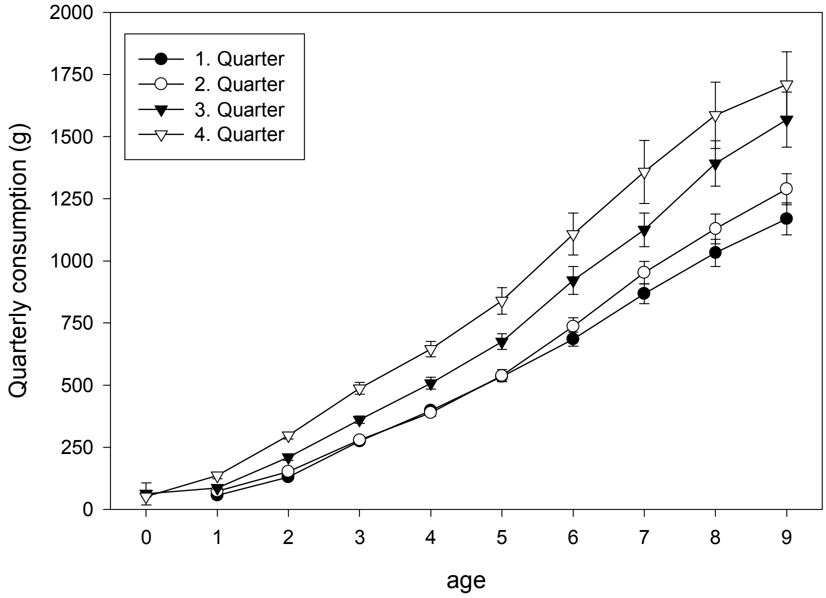


Fig. 5.2.5. Quarterly consumption of cod (averages over years 1977-1997) with corresponding standard error estimated with the new model, incorporating actual ambient temperatures and predator weight, in combined Subdivisions 25, 26 & 28.

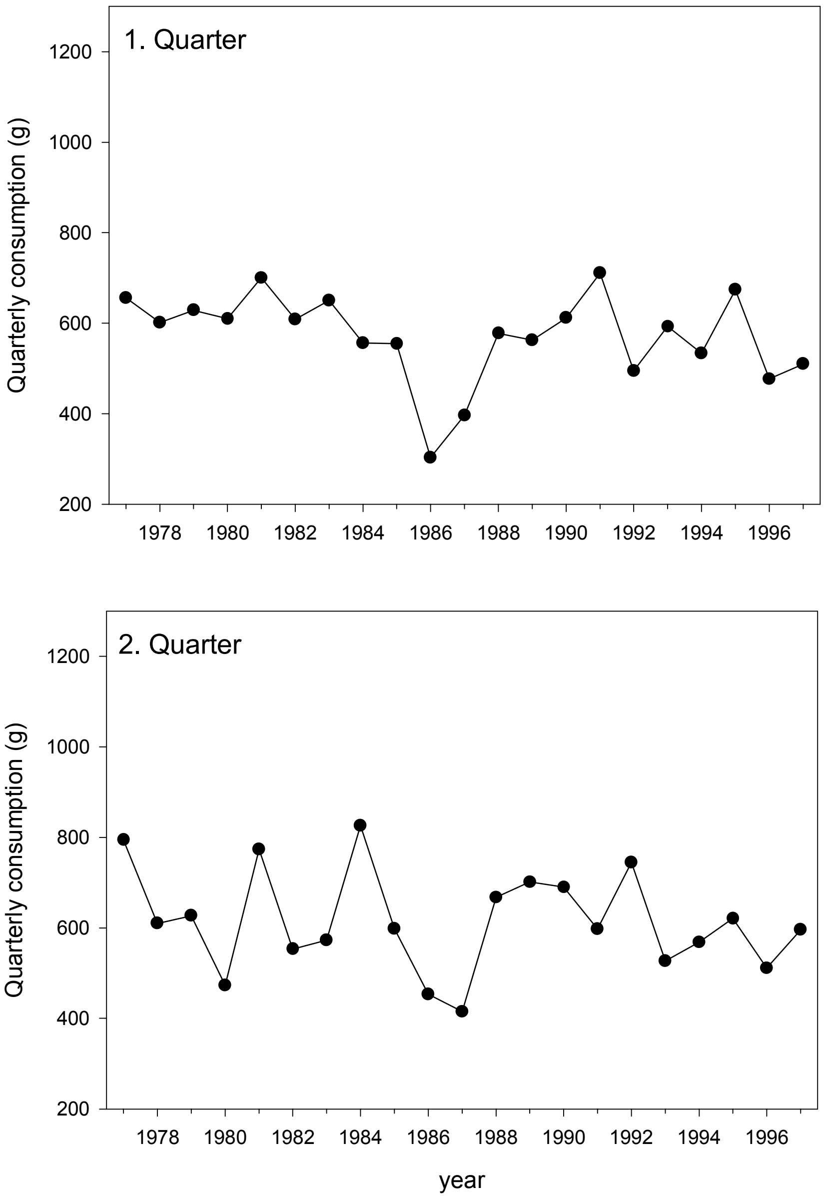


Fig. 5.2.6a. Quarterly cod consumption rates (averages over ages 1-9) with corresponding standard error for the 1st (above) and the 2nd (below) quarter estimated with the new model, incorporating actual ambient temperatures and predator weight, in combined Subdivisions 25, 26 & 28.

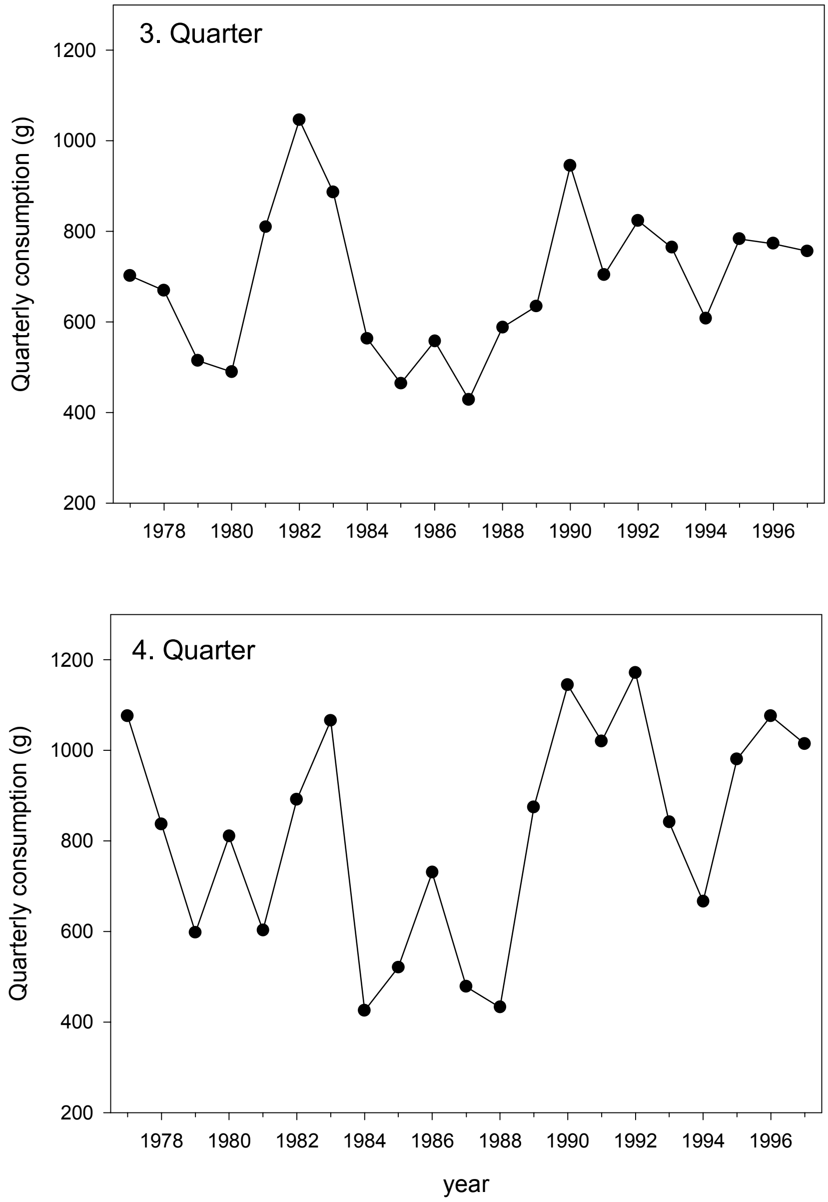


Fig. 5.2.6b. Quarterly cod consumption rates (averages over ages 1-9) with corresponding standard error for the 3rd (above) and the 4th (below) quarter estimated with the new model, incorporating actual ambient temperatures and predator weight, in combined Subdivisions 25, 26 & 28.

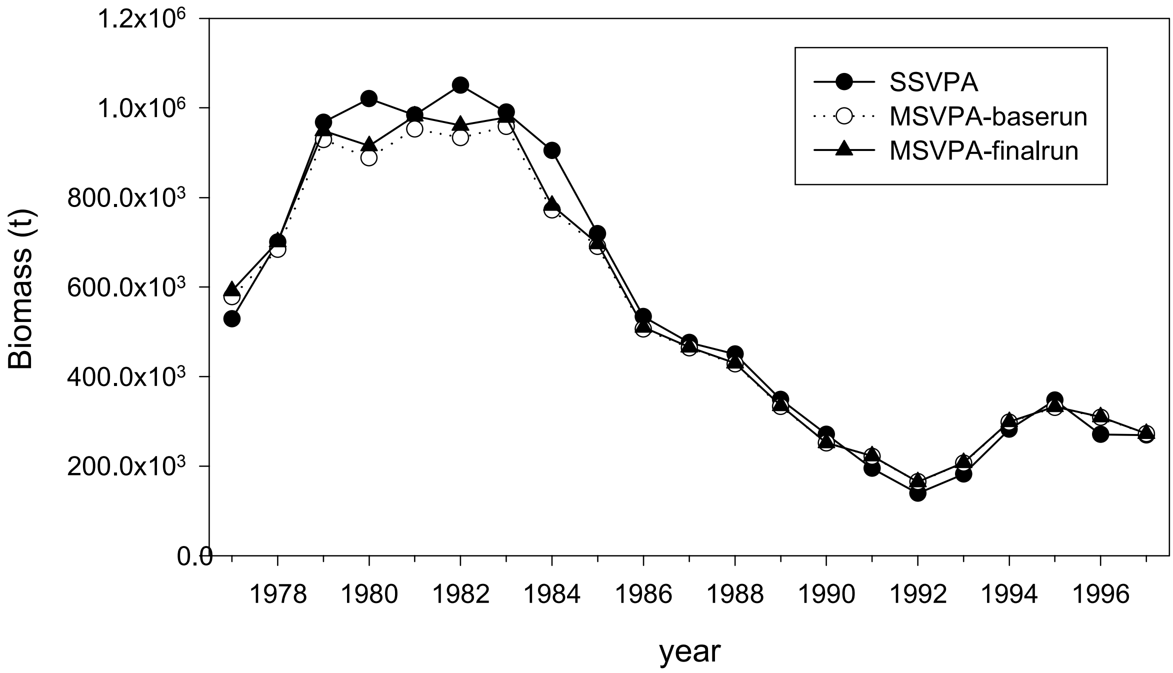


Figure 5.2.7a. Comparison of single-species assessment (SSVPA; ICES 1998/Assess:16) with MSVPA-runs: Cod total biomass (t).

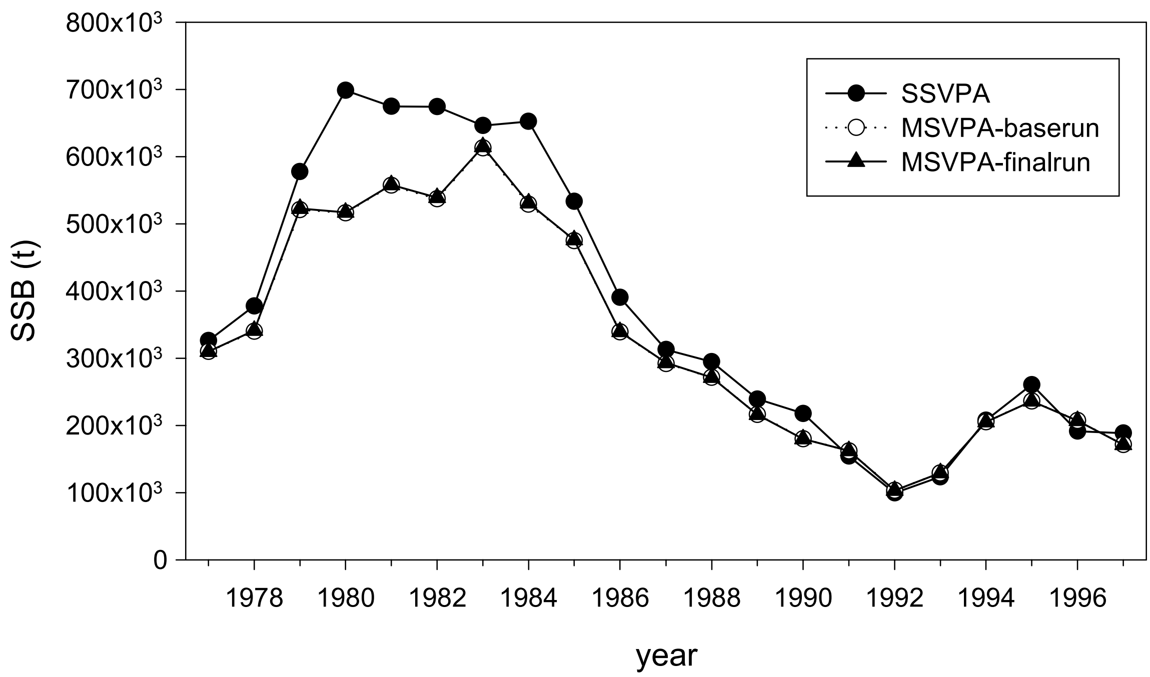


Figure 5.2.7b. Comparison of single-species assessment (SSVPA; ICES 1998/Assess:16) with MSVPA-runs: Cod spawning stock biomass (t).

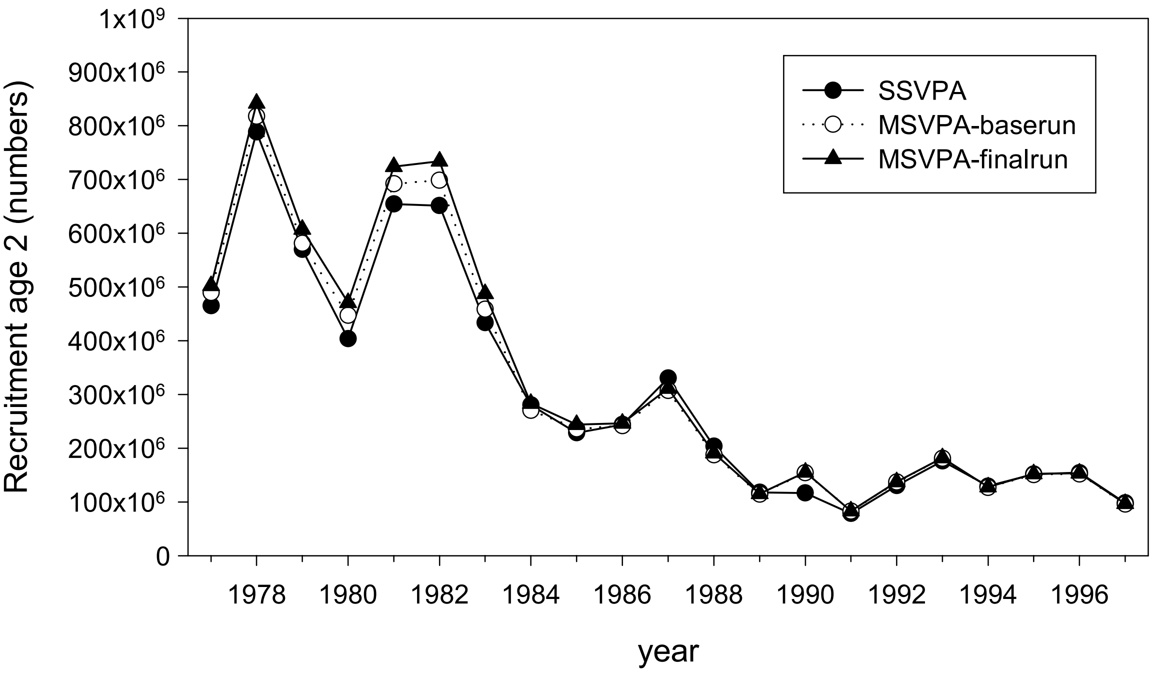


Figure 5.2.8. Comparison of single-species assessment (SSVPA; ICES 1998/Assess: 16) with MSVPA-runs: Cod recruitment at age 2 (numbers).

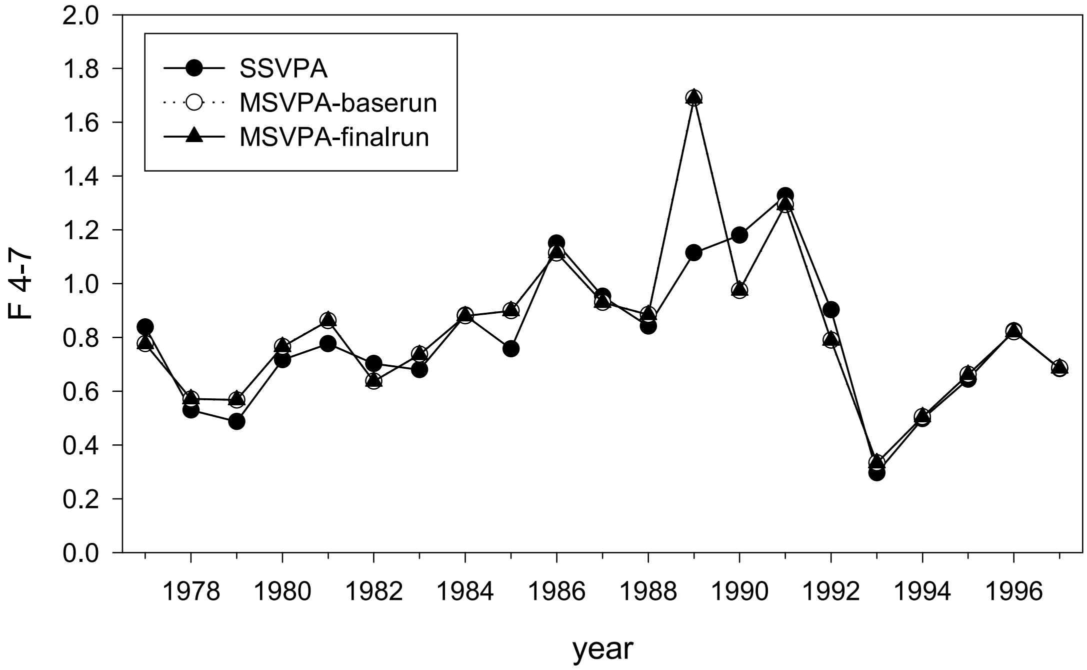


Figure 5.2.9. Comparison of single-species assessment (SSVPA; ICES 1998/Assess: 16) with MSVPA-runs: Cod fishing mortality (average F ages 4-7).

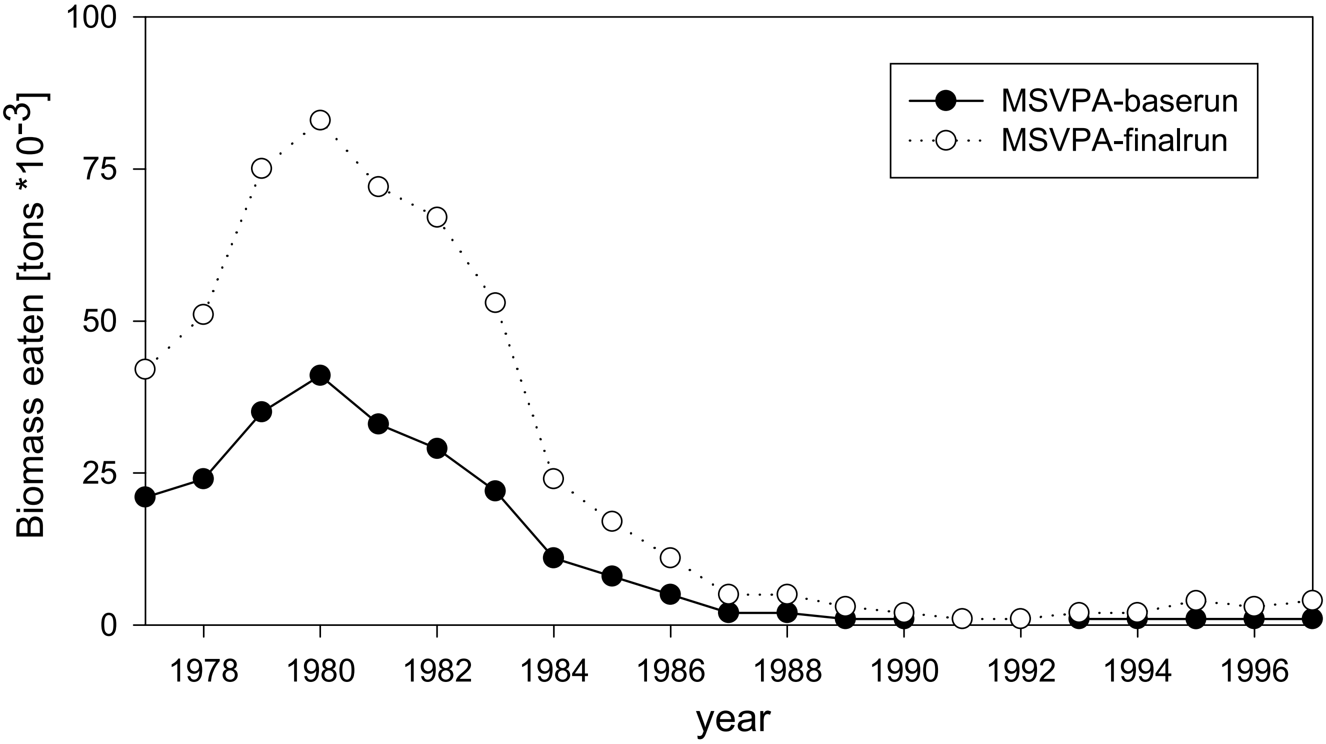


Figure 5.2.10. Comparison of the MSVPA base run (old suitability sub-model) and the MSVPA final run (new suitability sub-model): Cod biomass eaten by cod.

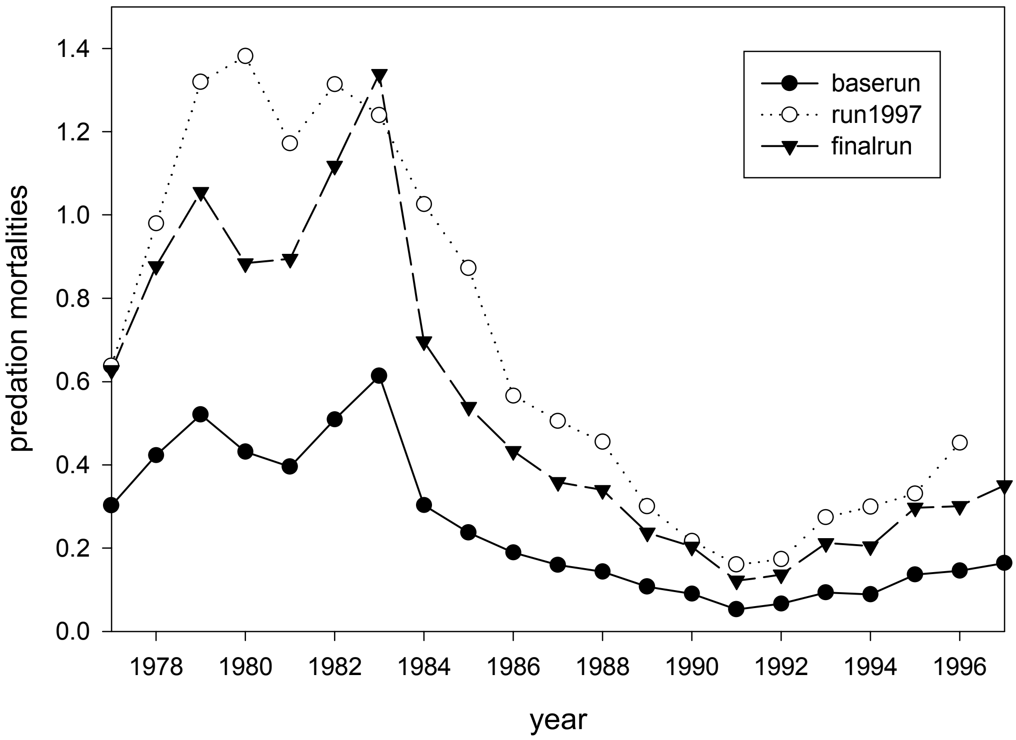


Figure 5.2.11a. Comparison of MSVPA baserun, finalrun and the run conducted during the meeting of the Baltic Fisheries Assessment Working Group in 1997 (ICES 1997/Assess:12): O-group cod predation mortalities.

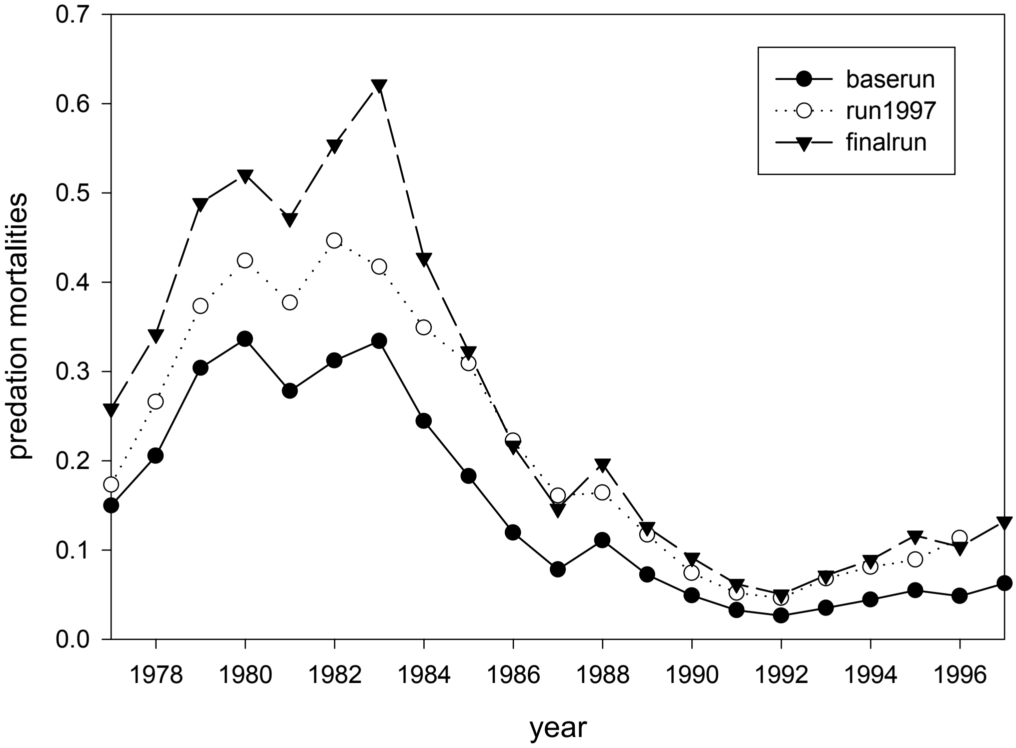


Figure 5.2.11b. Comparison of MSVPA baserun, finalrun and the run conducted during the meeting of the Baltic Fisheries Assessment Working Group in 1997 (ICES 1997/Assess:12): Age-group 1 cod predation mortalities.

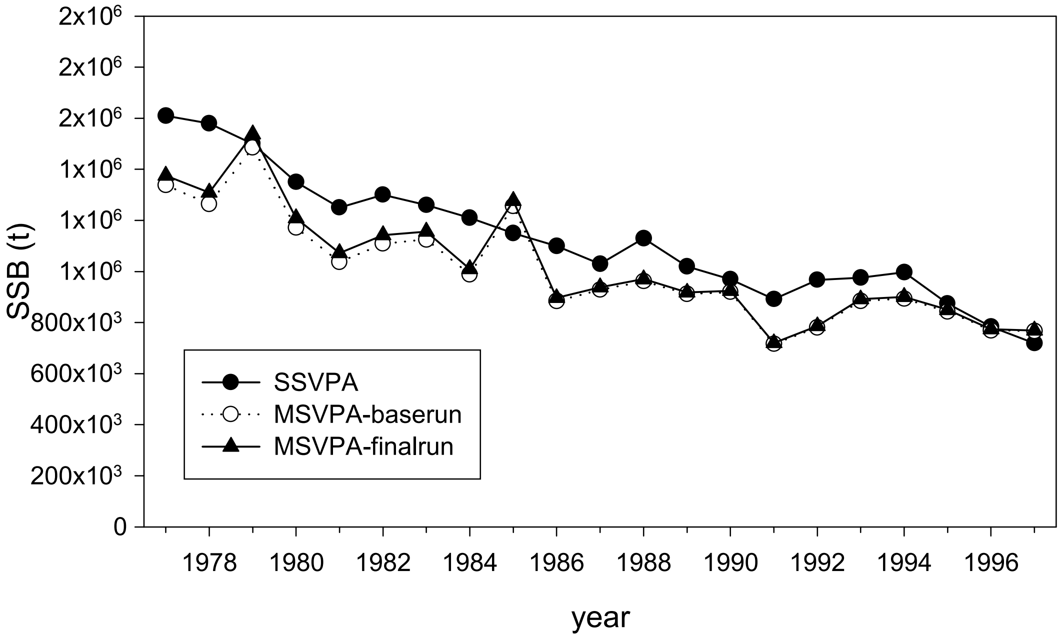


Figure 5.2.12a. Comparison of single-species assessment (SSVPA; ICES 1998/Assess:16) with the MSVPA-runs: Herring spawning stock biomass (t).

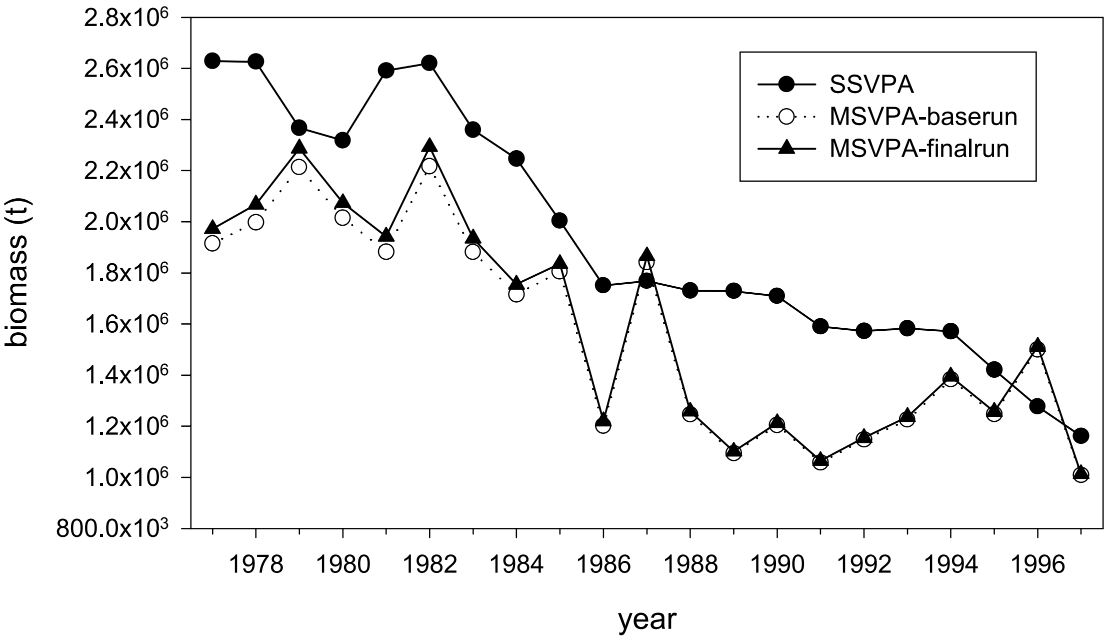


Figure 5.2.12b. Comparison of single-species assessment (SSVPA; ICES 1998/Assess:16) with the MSVPA-runs: Herring total biomass (t).

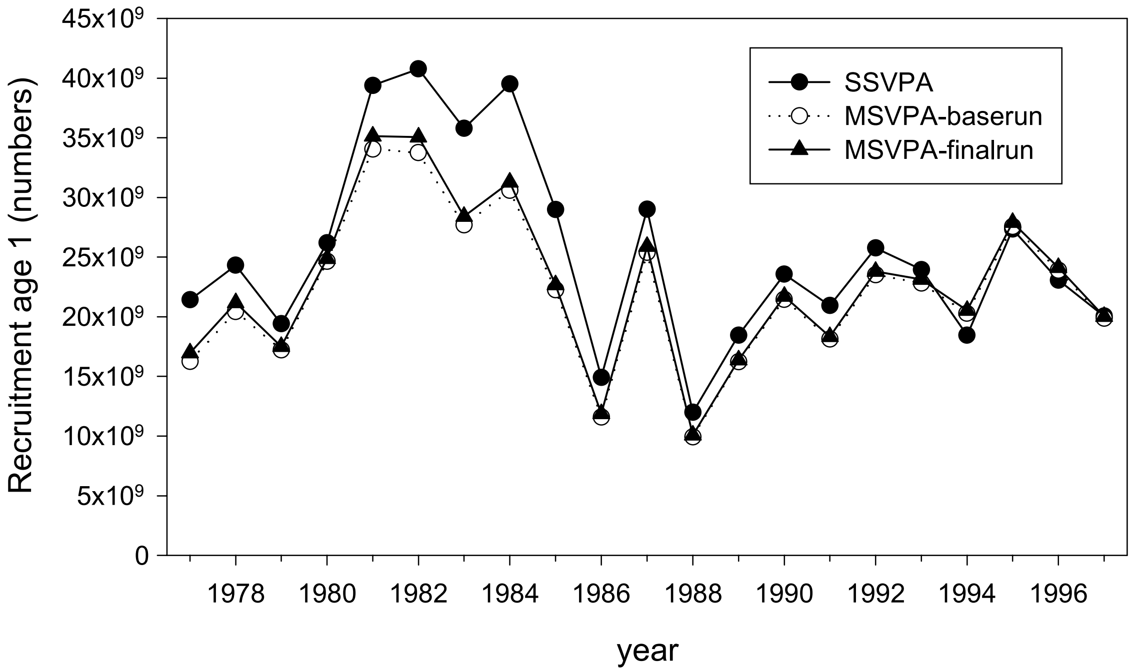


Figure 5.2.13. Comparison of single-species assessment (SSVPA; ICES 1998/Assess:16) with the MSVPA-runs: Herring recruitment at age 1 (numbers).

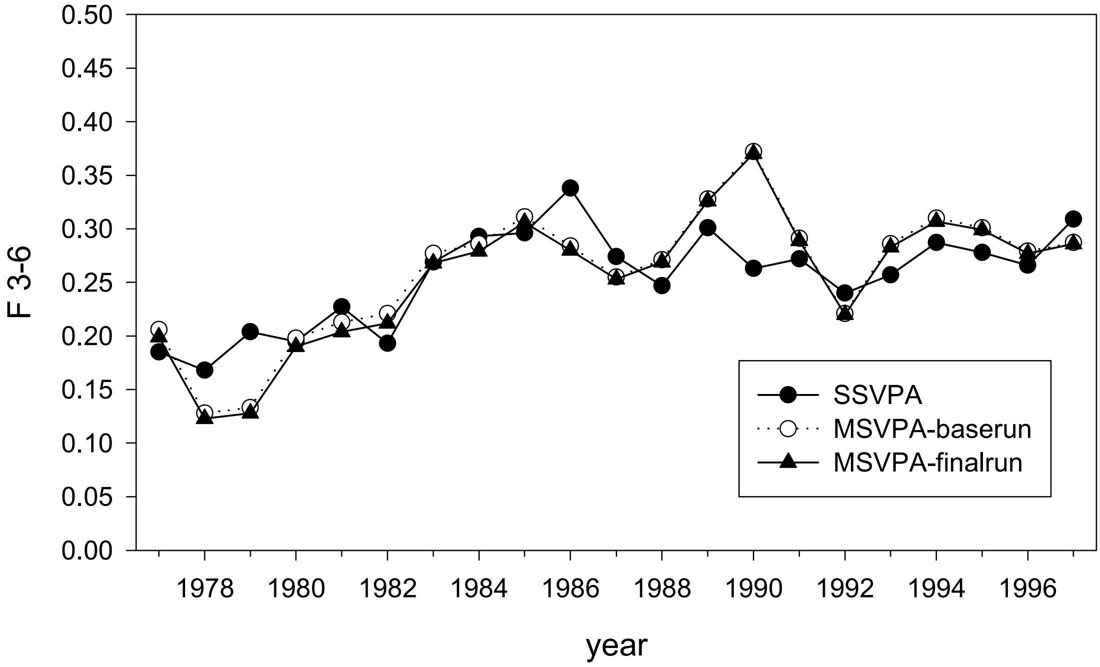


Figure 5.2.14. Comparison of single-species assessment (SSVPA; ICES 1998/Assess:16) with the MSVPA-runs: Herring fishing mortality (F 3-6).

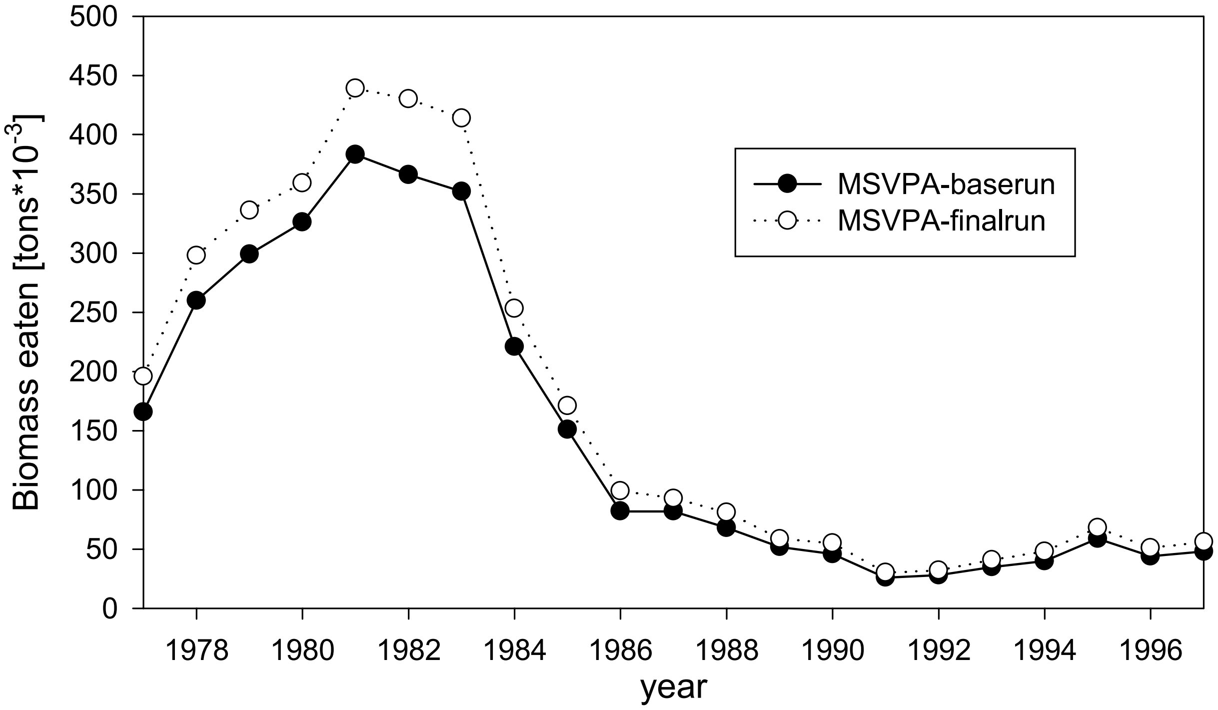


Figure 5.2.15. Comparison of the MSVPA base run (old suitability sub-model) and the MSVPA final run (new suitability sub-model): Herring biomass eaten by cod.

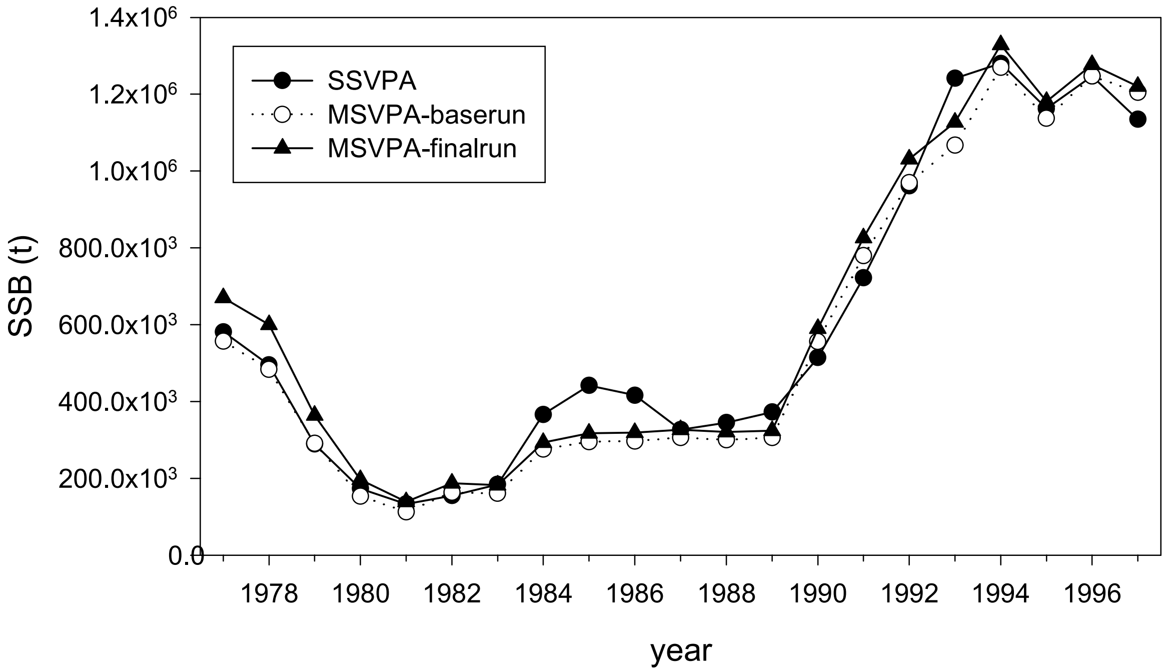


Figure 5.2.16a. Comparison of single-species assessment (SSVPA; ICES 1998/Assess:16) with the MSVPA-runs: Sprat spawning stock biomass (t).

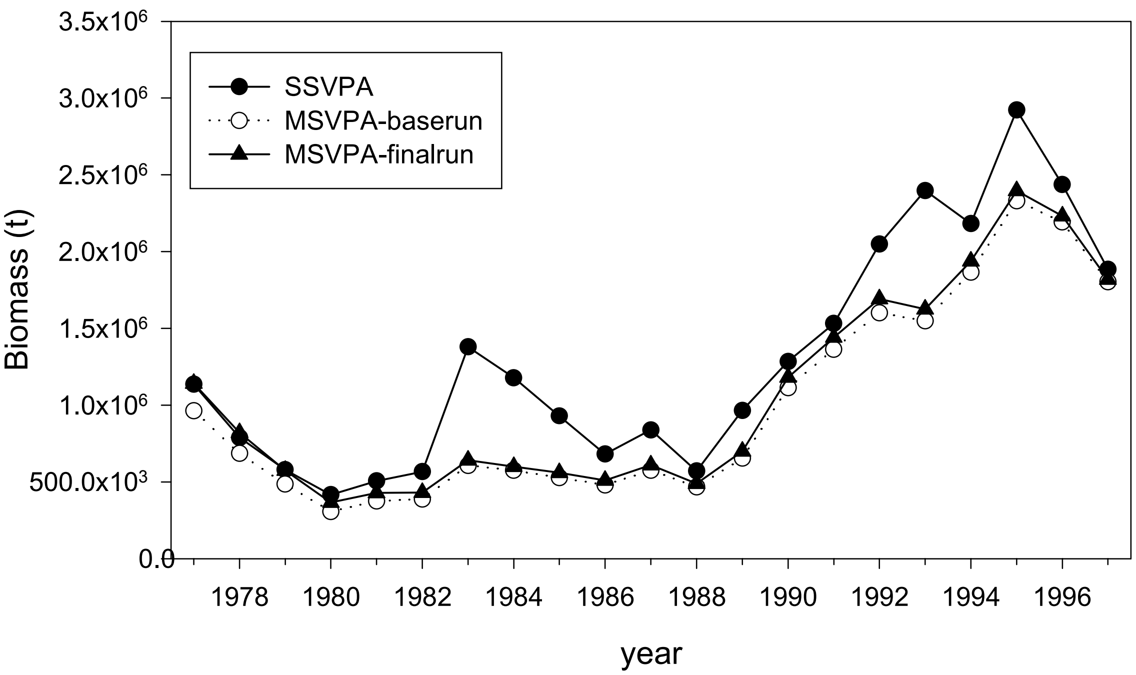


Figure 5.2.16b. Comparison of single-species assessment (SSVPA; ICES 1998/Assess:16) with the MSVPA-runs: Sprat total biomass (t).

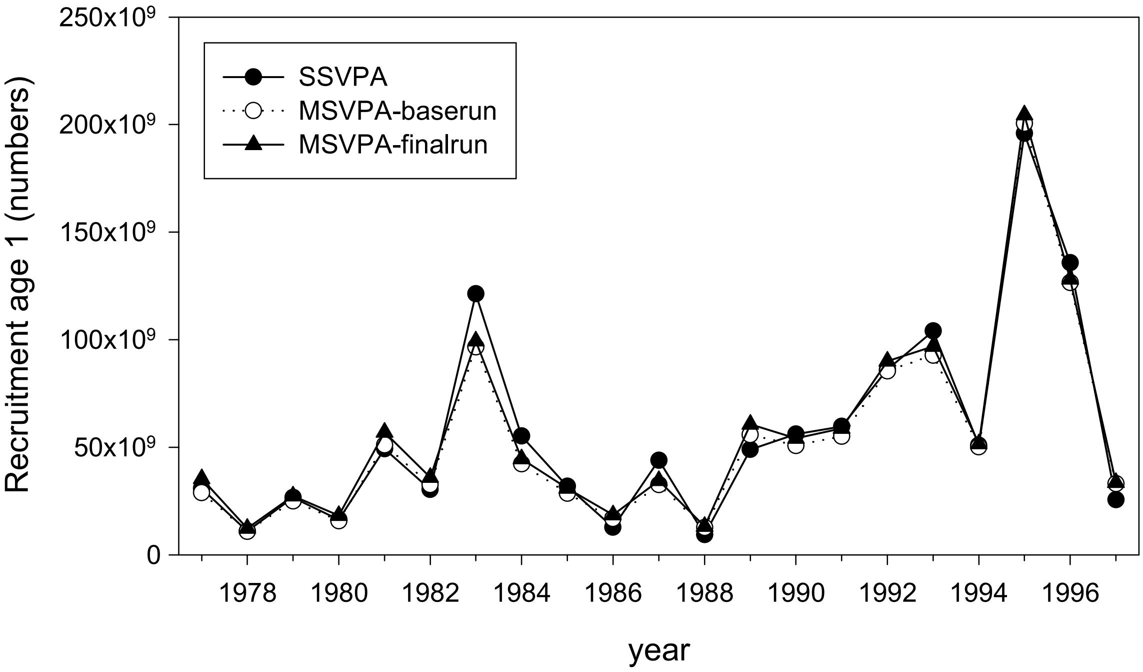


Figure 5.2.17. Comparison of single-species assessment (SSVPA; ICES 1998/Assess:16) with the MSVPA-runs: Sprat recruitment at age 1 (numbers).

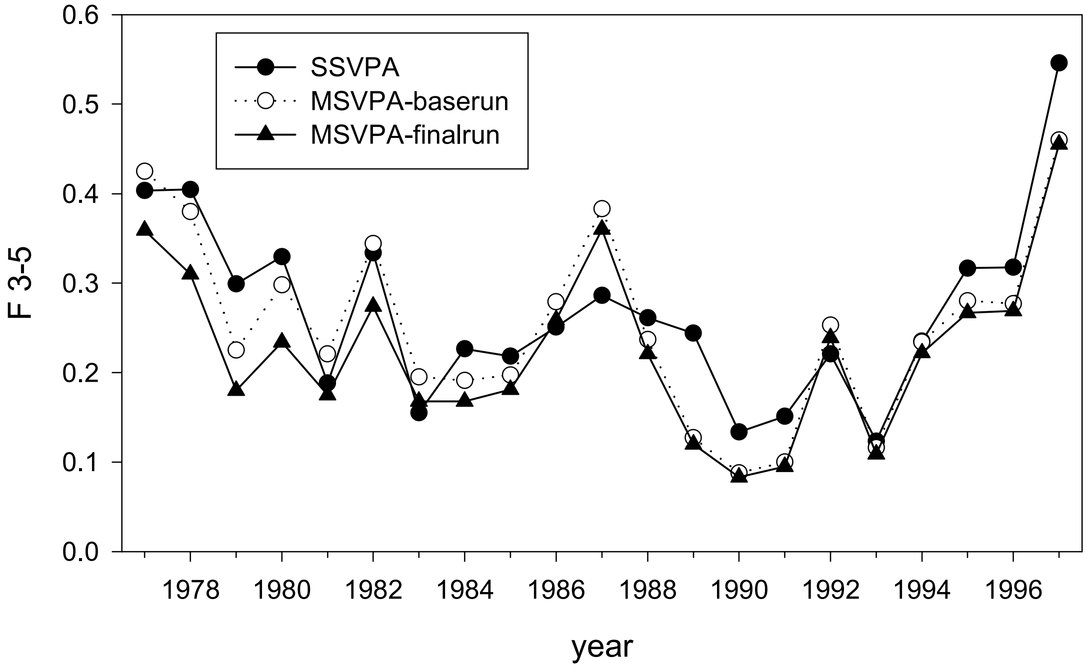


Figure 5.2.18. Comparison of single-species assessment (SSVPA; ICES 1998/Assess:16) with the MSVPA-runs: Sprat fishing mortality (average F ages 3-5).

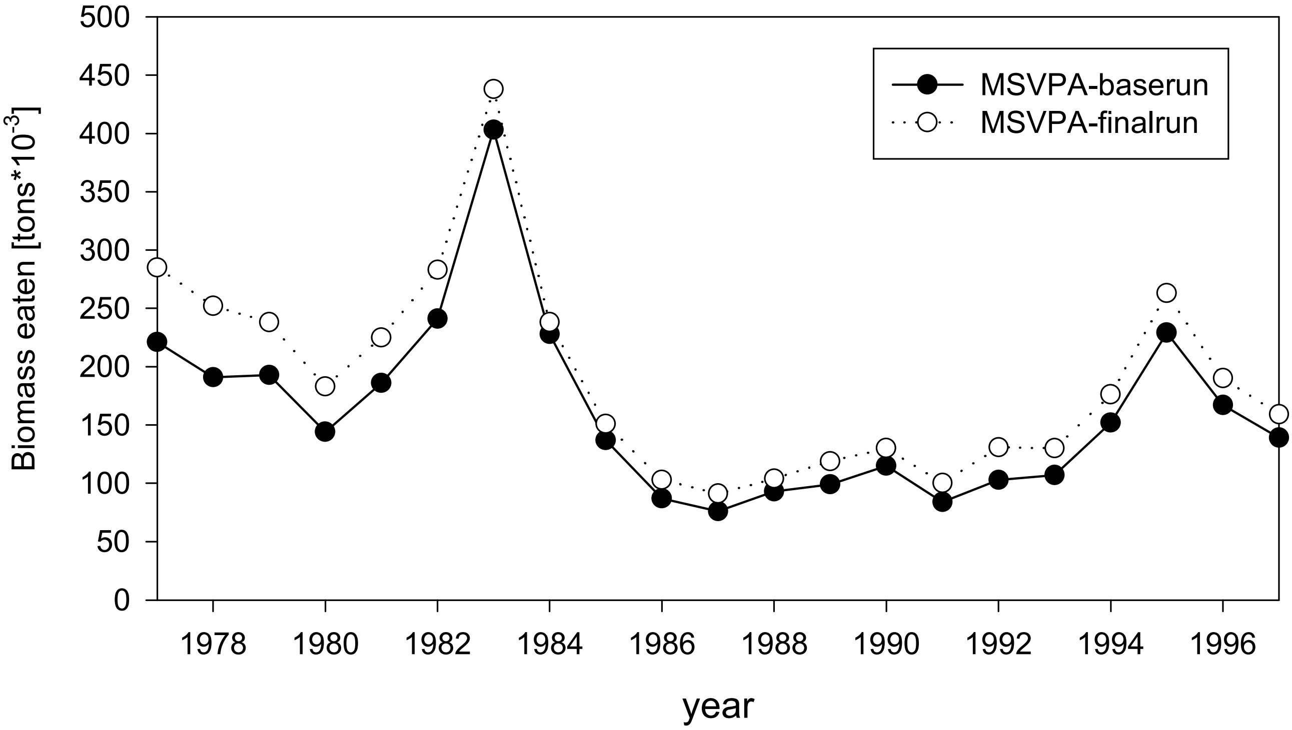


Figure 5.2.19. Comparison of the MSVPA base run (old suitability sub-model) and the MSVPA final run (new suitability sub-model): Sprat biomass eaten by cod.

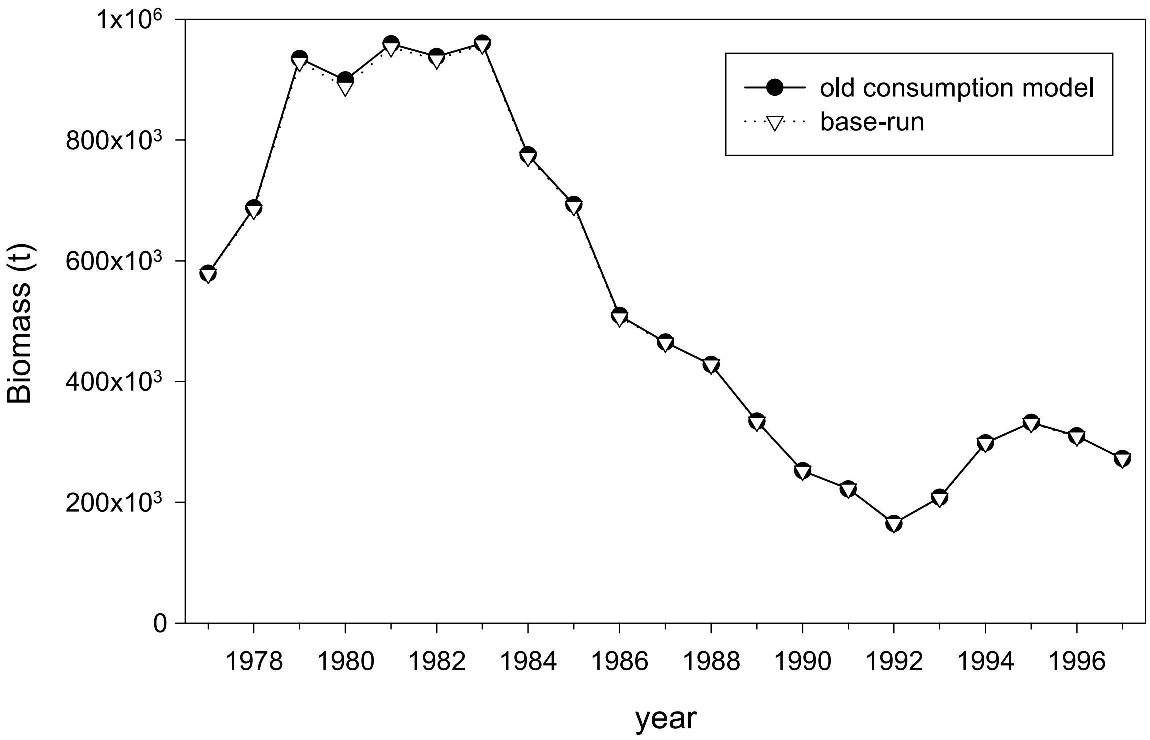


Figure 5.2.20a. Comparison of MSVPA-runs on basis of the new and the old gastric evacuation model: Cod total biomass (t).

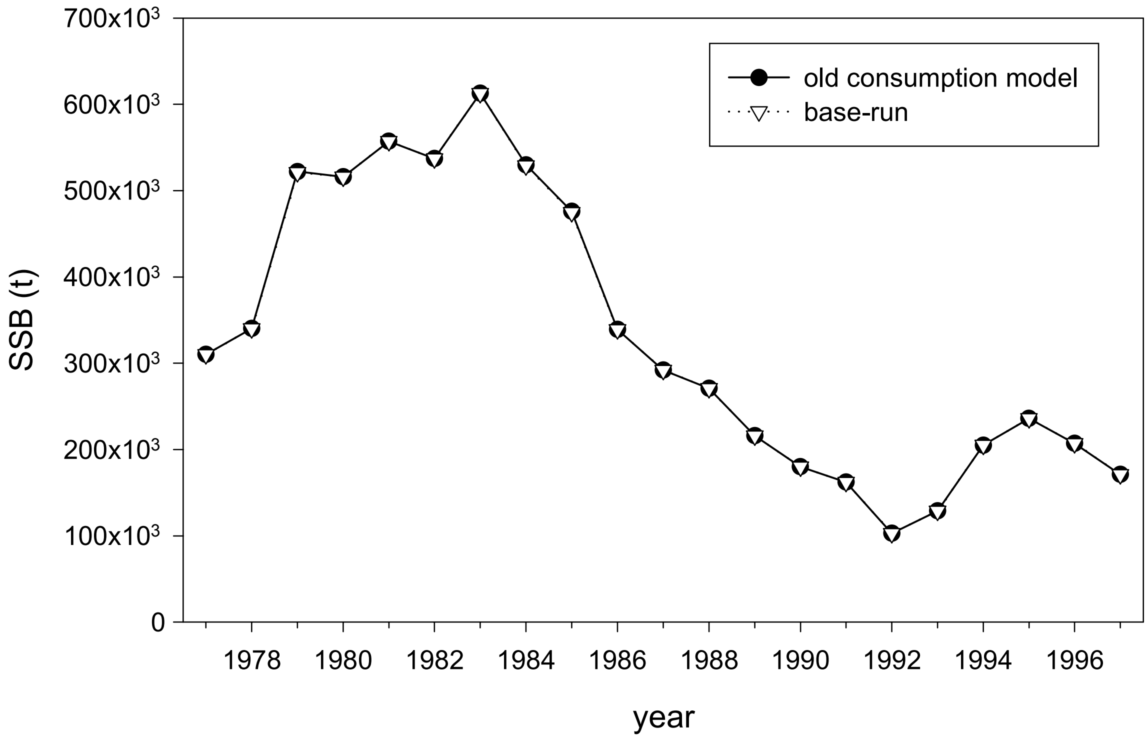


Figure 5.2.20b. Comparison of MSVPA-runs on basis of the new and the old gastric evacuation model: Cod spawning stock biomass (t).

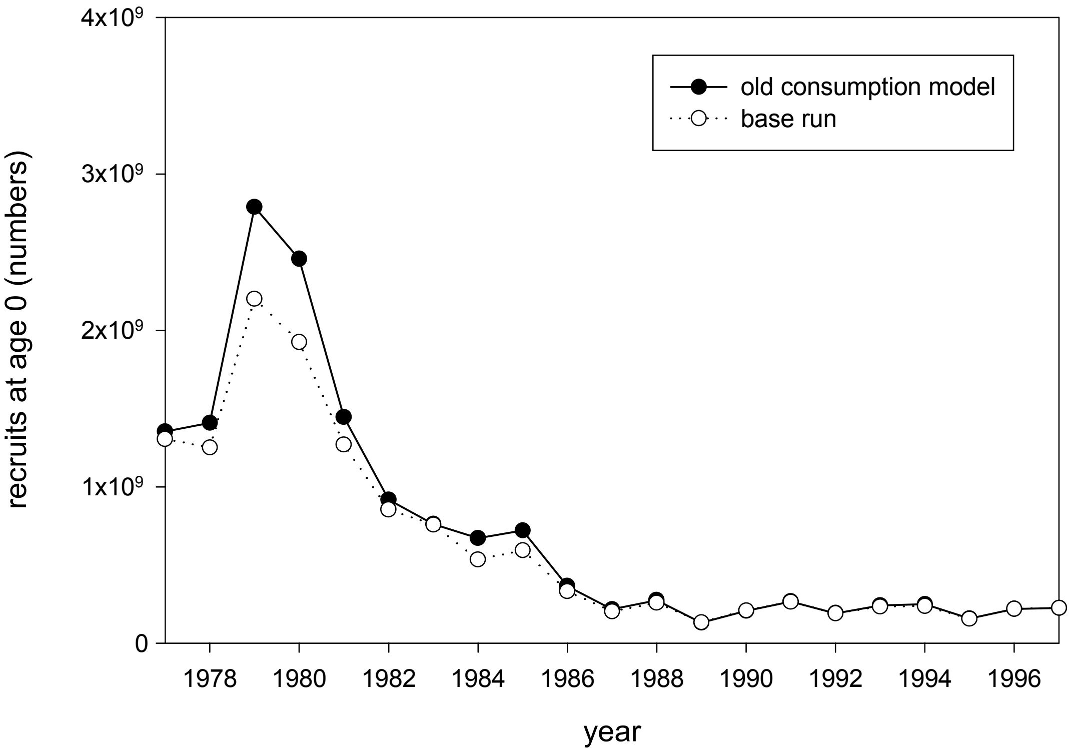


Figure 5.2.21a. Comparison of MSVPA-runs on basis of the new and the old gastric evacuation model: Cod recruits at age 0 (numbers).

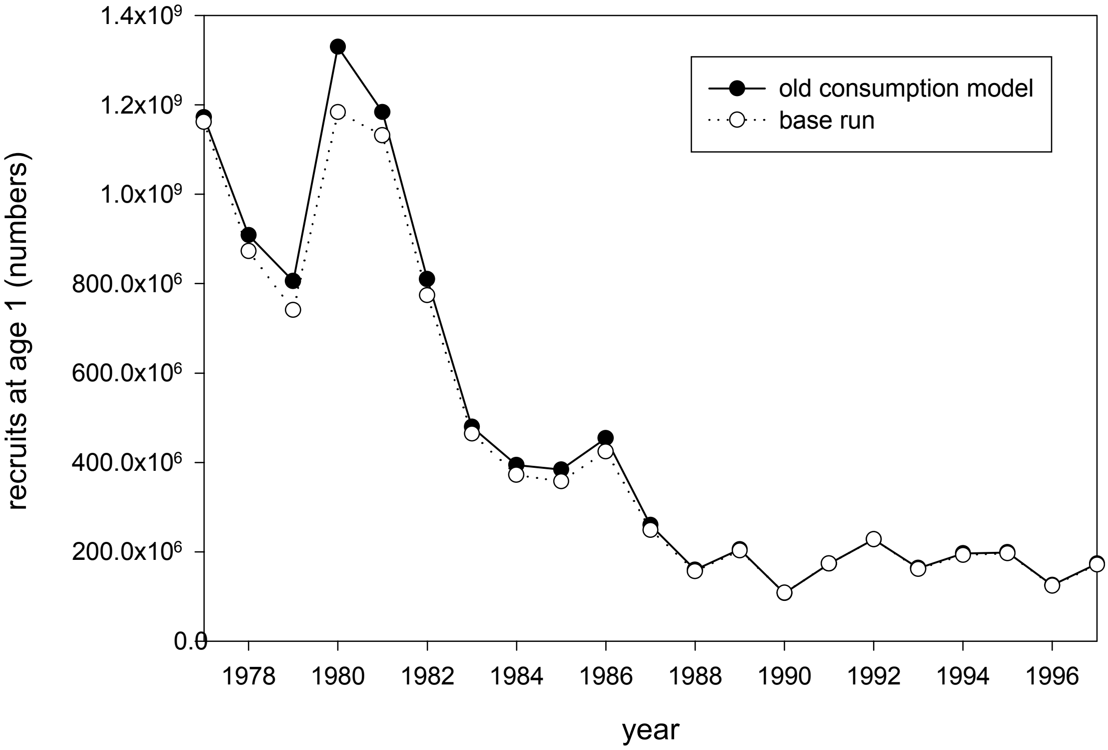


Figure 5.2.21b. Comparison of MSVPA-runs on basis of the new and the old gastric evacuation model: Cod recruits at age 1 (numbers).

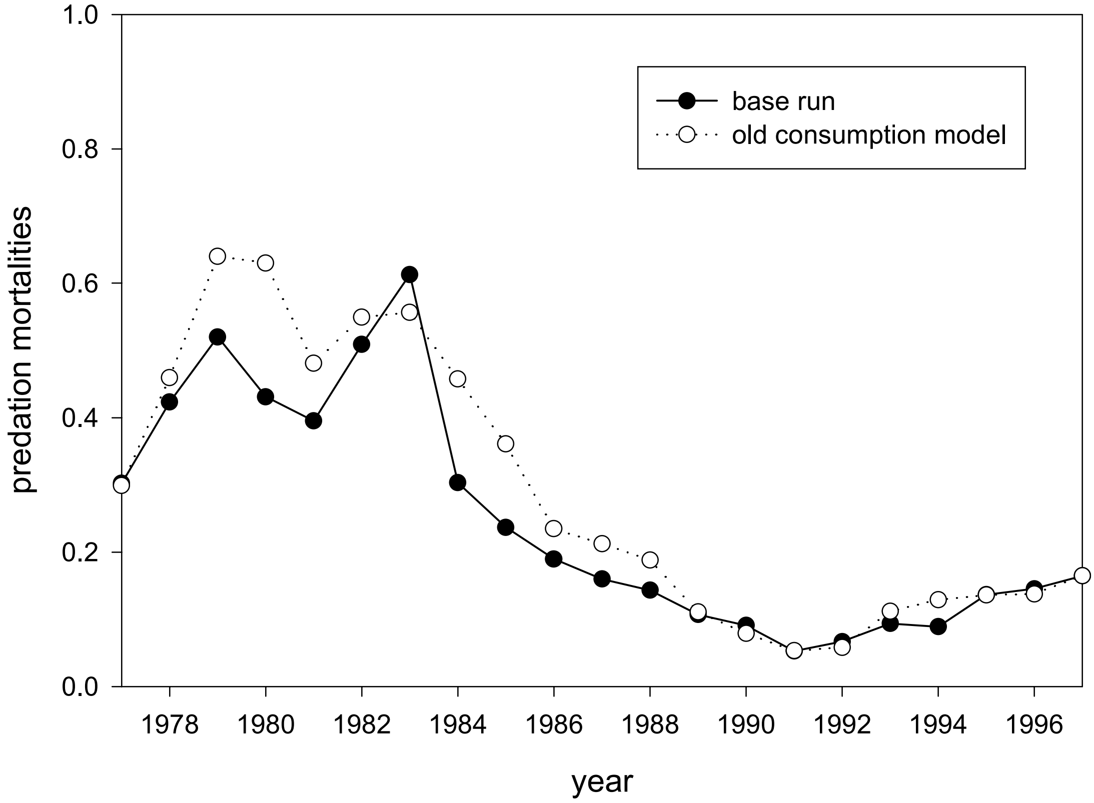


Figure 5.2.22a. Comparison of MSVPA-runs on basis of the new and the old gastric evacuation model: Predation mortalities for O-group cod.

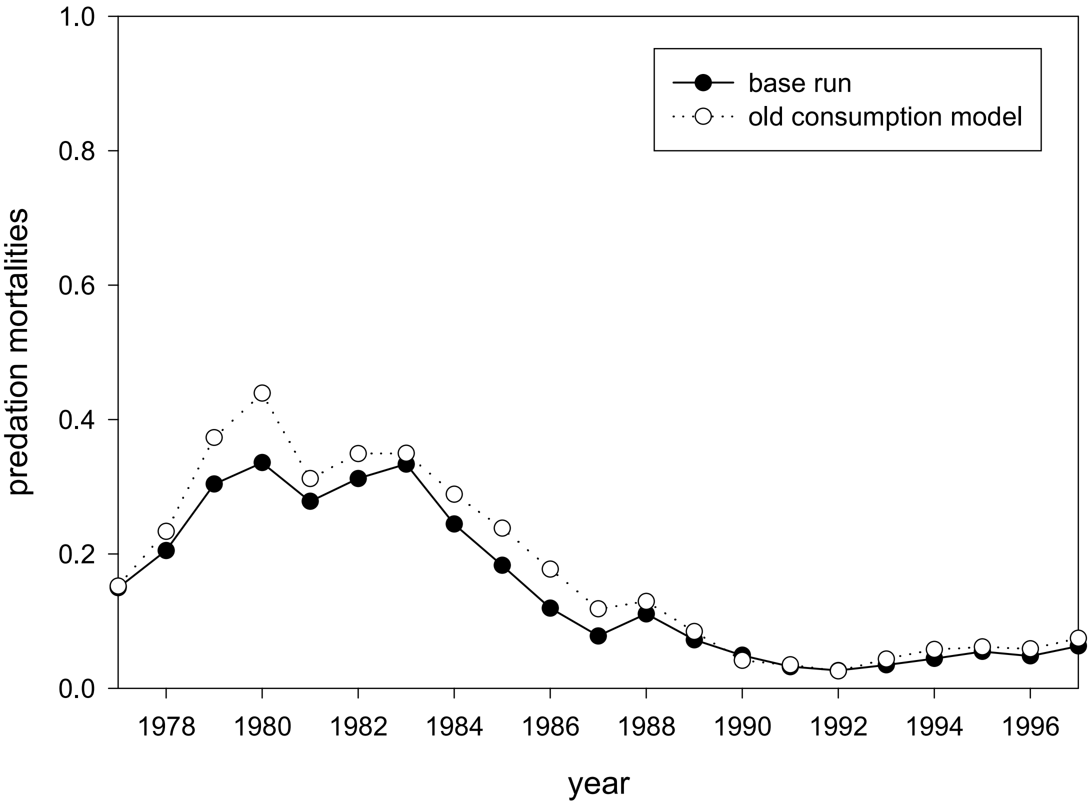


Figure 5.2.22b. Comparison of MSVPA-runs on basis of the new and the old gastric evacuation model: Predation mortalities for 1-group cod.

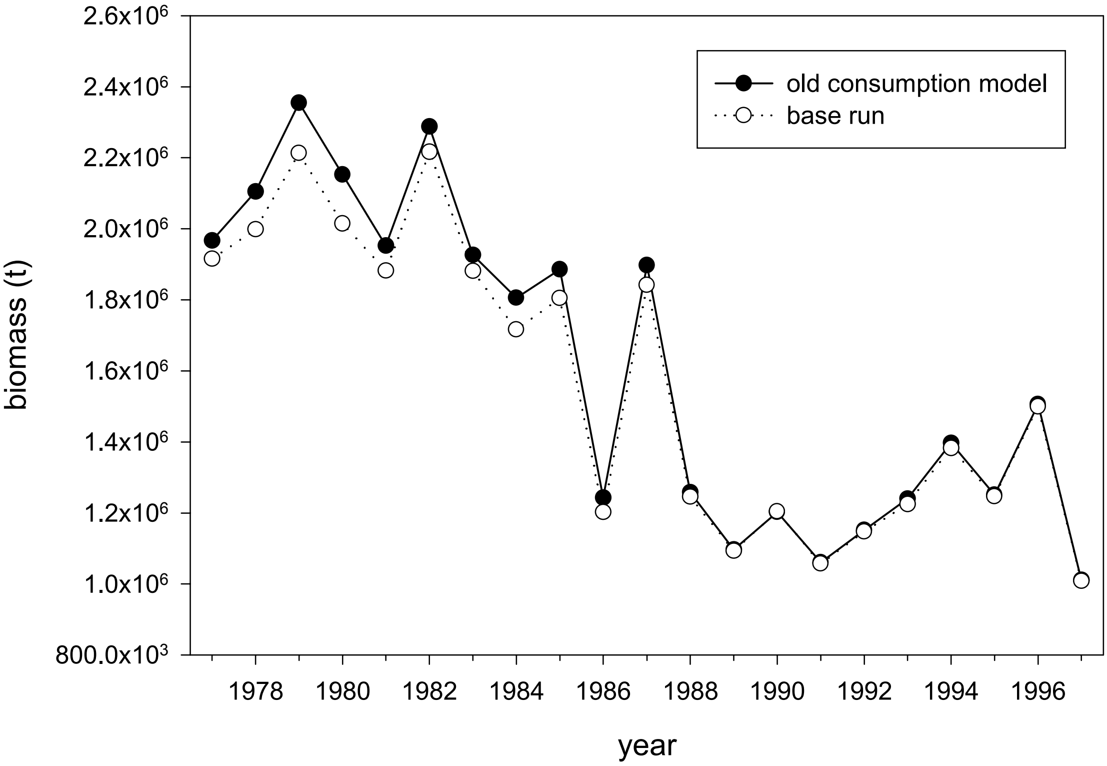


Figure 5.2.23a. Comparison of MSVPA-runs on basis of the new and the old gastric evacuation model: Herring total biomass (t).

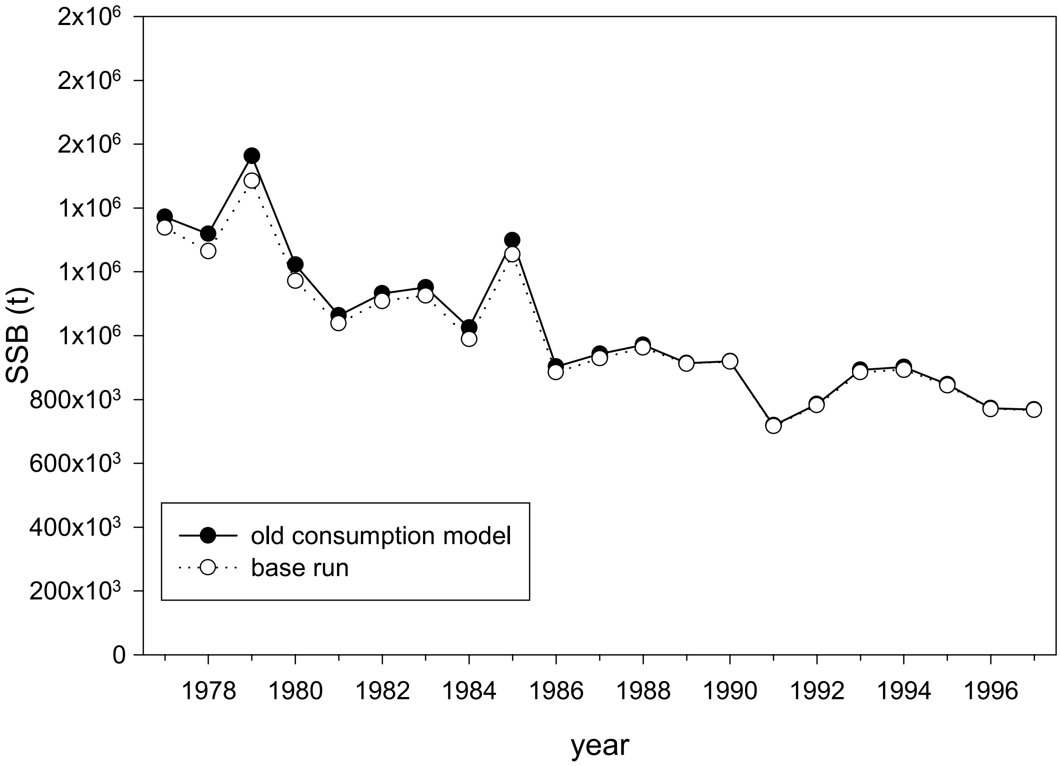


Figure 5.2.23b. Comparison of MSVPA-runs on basis of the new and the old gastric evacuation model: Herring spawning stock biomass (t).

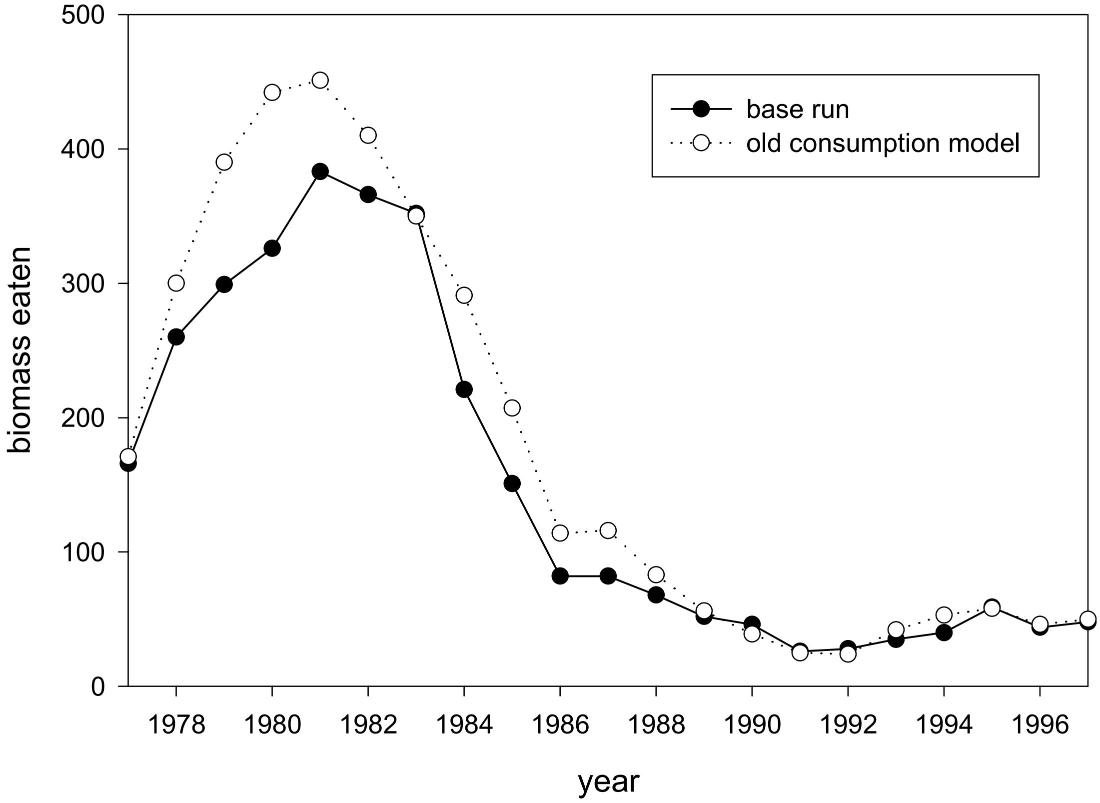


Figure 5.2.24. Comparison of MSVPA-runs on basis of the new and the old gastric evacuation model: Herring biomass eaten by cod.

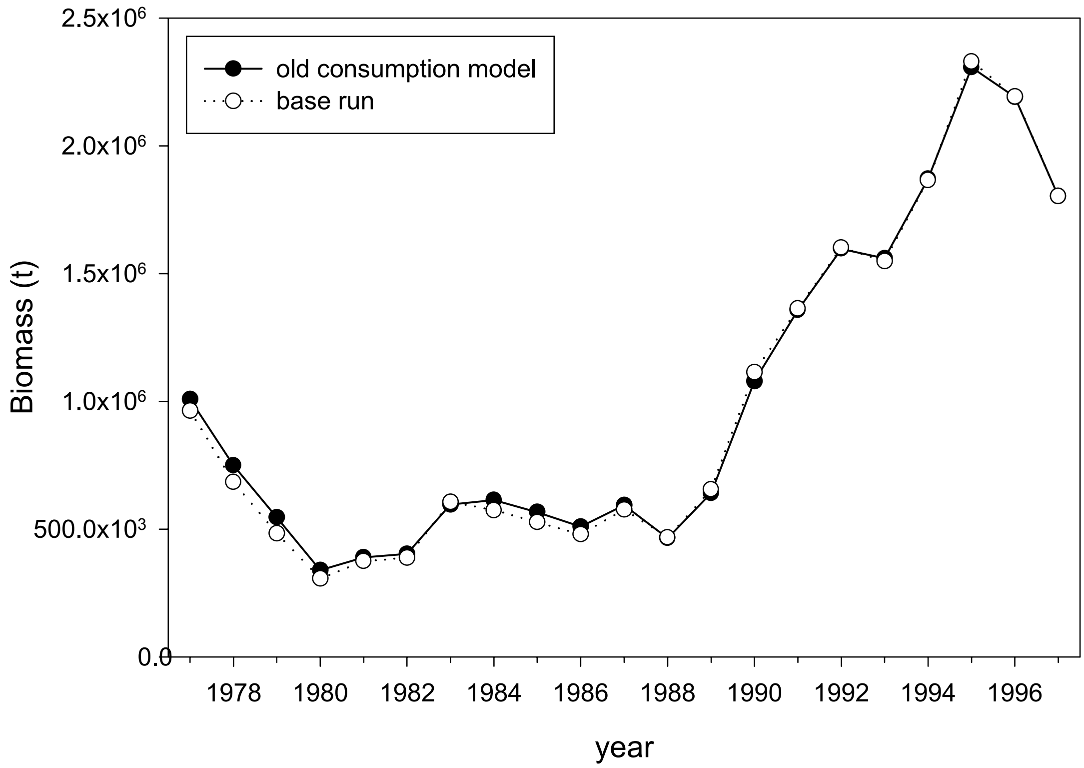


Figure 5.2.25a. Comparison of MSVPA-runs on basis of the new and the old gastric evacuation model: Sprat total biomass (t).

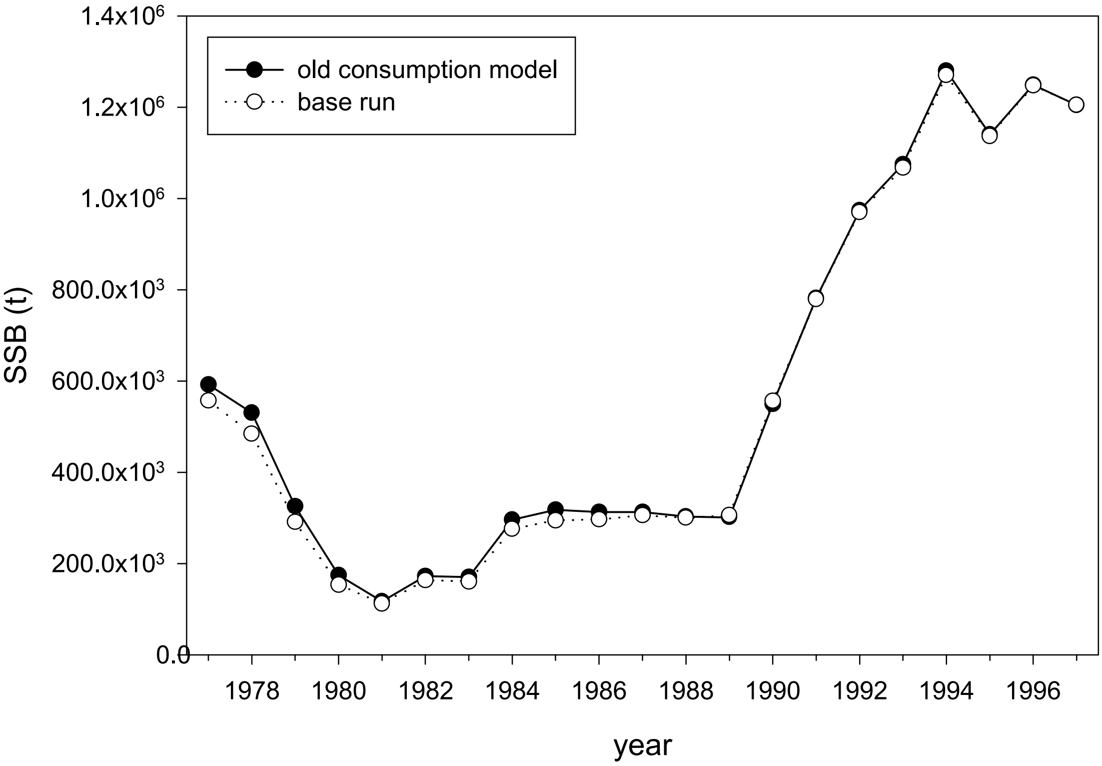


Figure 5.2.25b. Comparison of MSVPA-runs on basis of the new and the old gastric evacuation model as well as a preliminary bioernergetics model: Sprat spawning stock biomass (t).

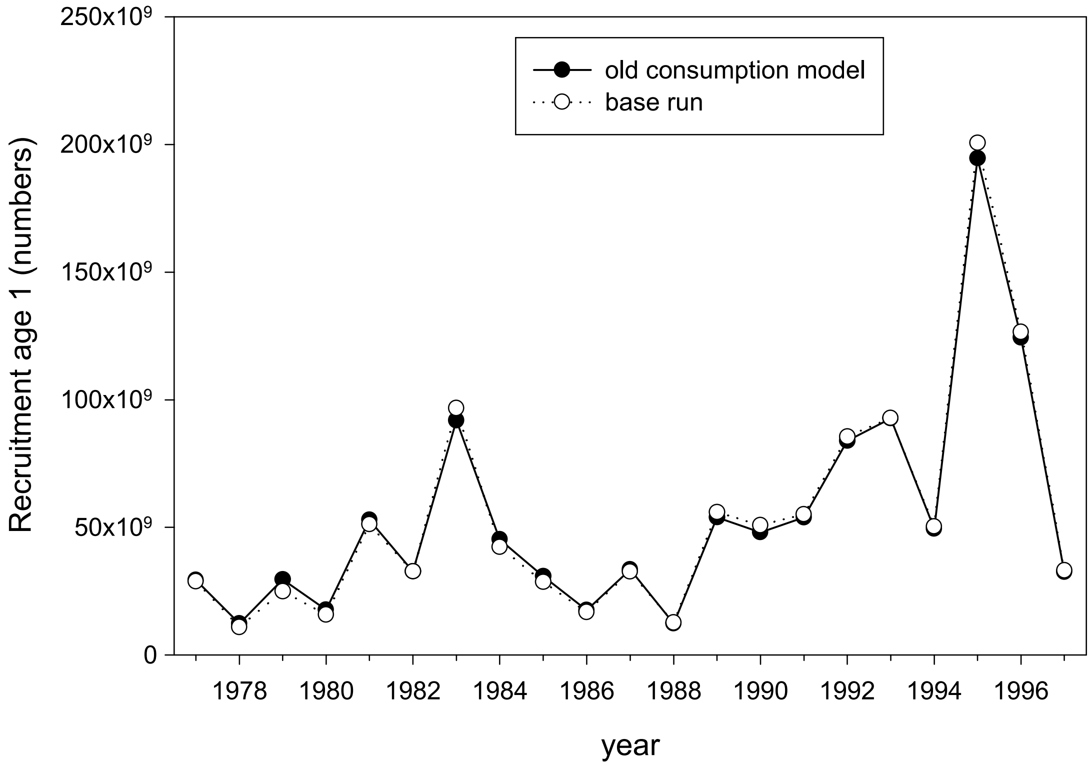


Figure 5.2.26. Comparison of MSVPA-runs on basis of the new and the old gastric evacuation model: Sprat recruits at age 1 (numbers).

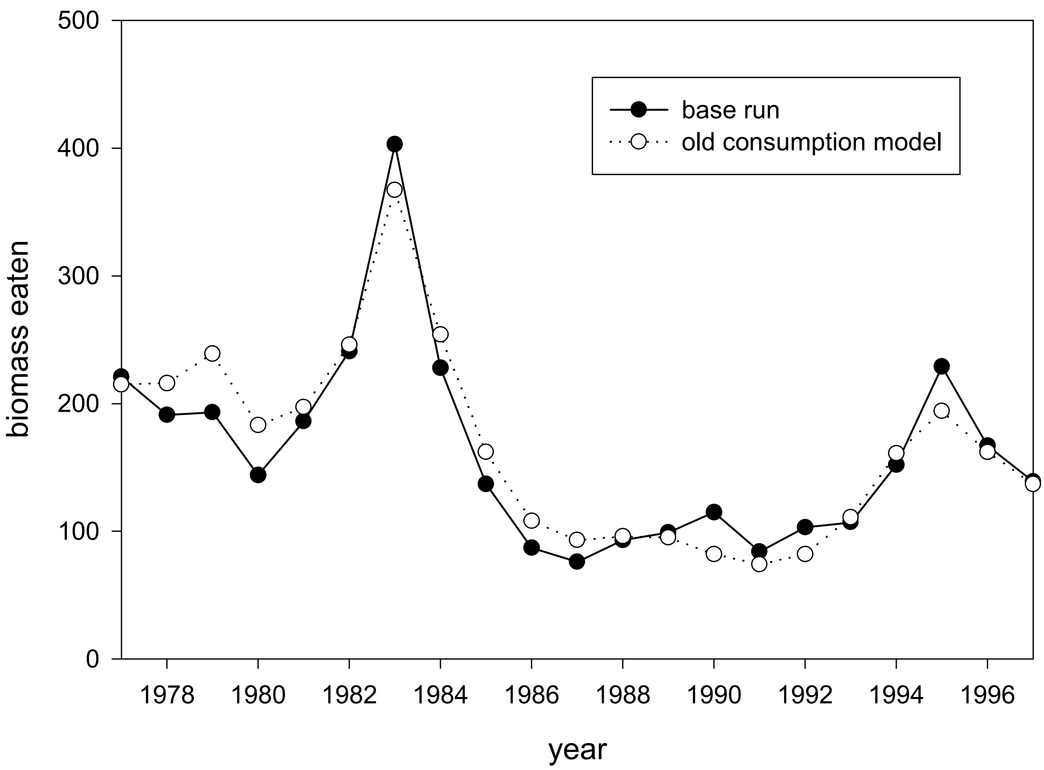


Figure 5.2.27. Comparison of MSVPA-runs on basis of the new and the old gastric evacuation model as well as a preliminary bioernergetics model: Sprat biomass eaten by cod.

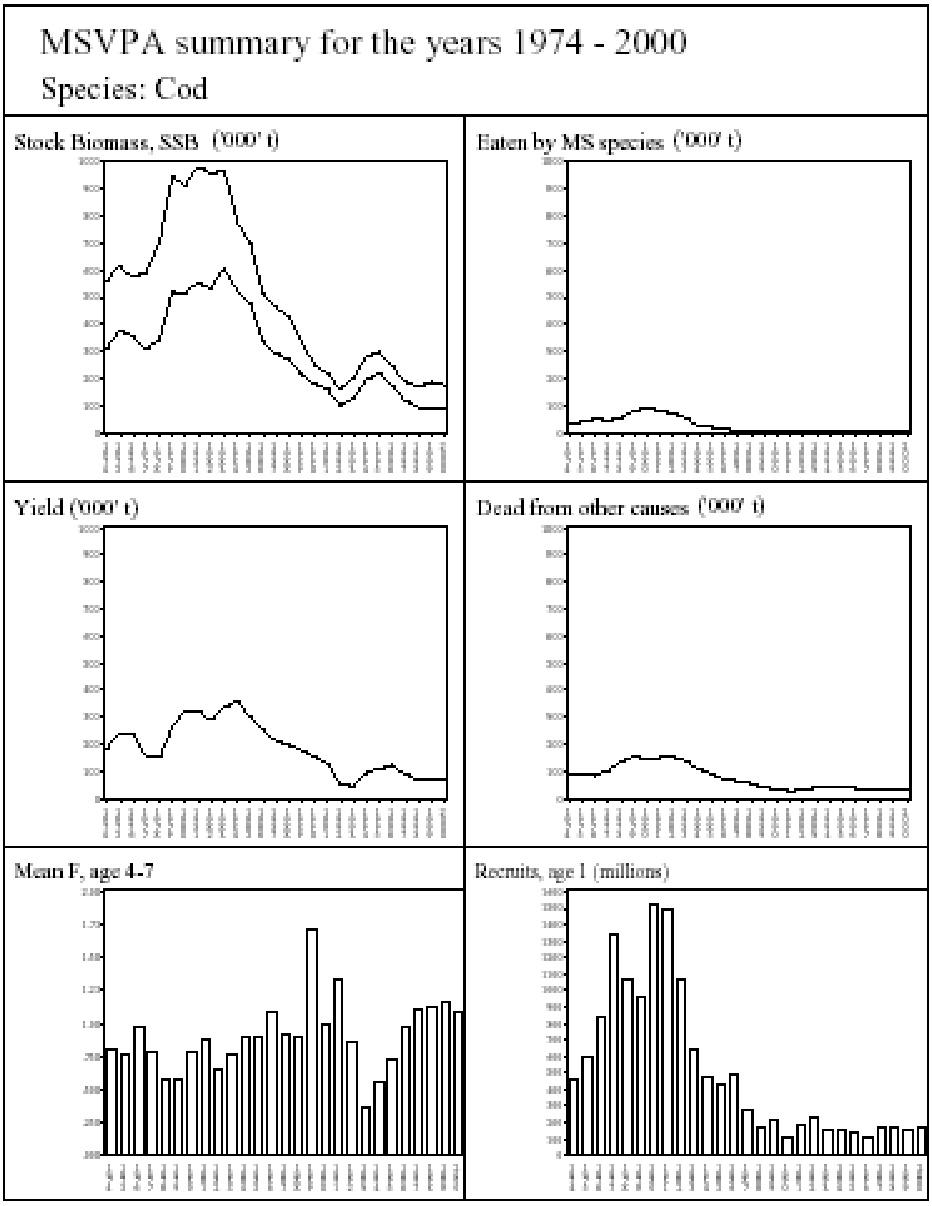


Fig. 5.2.28. Results of the MSVPA-run for cod.

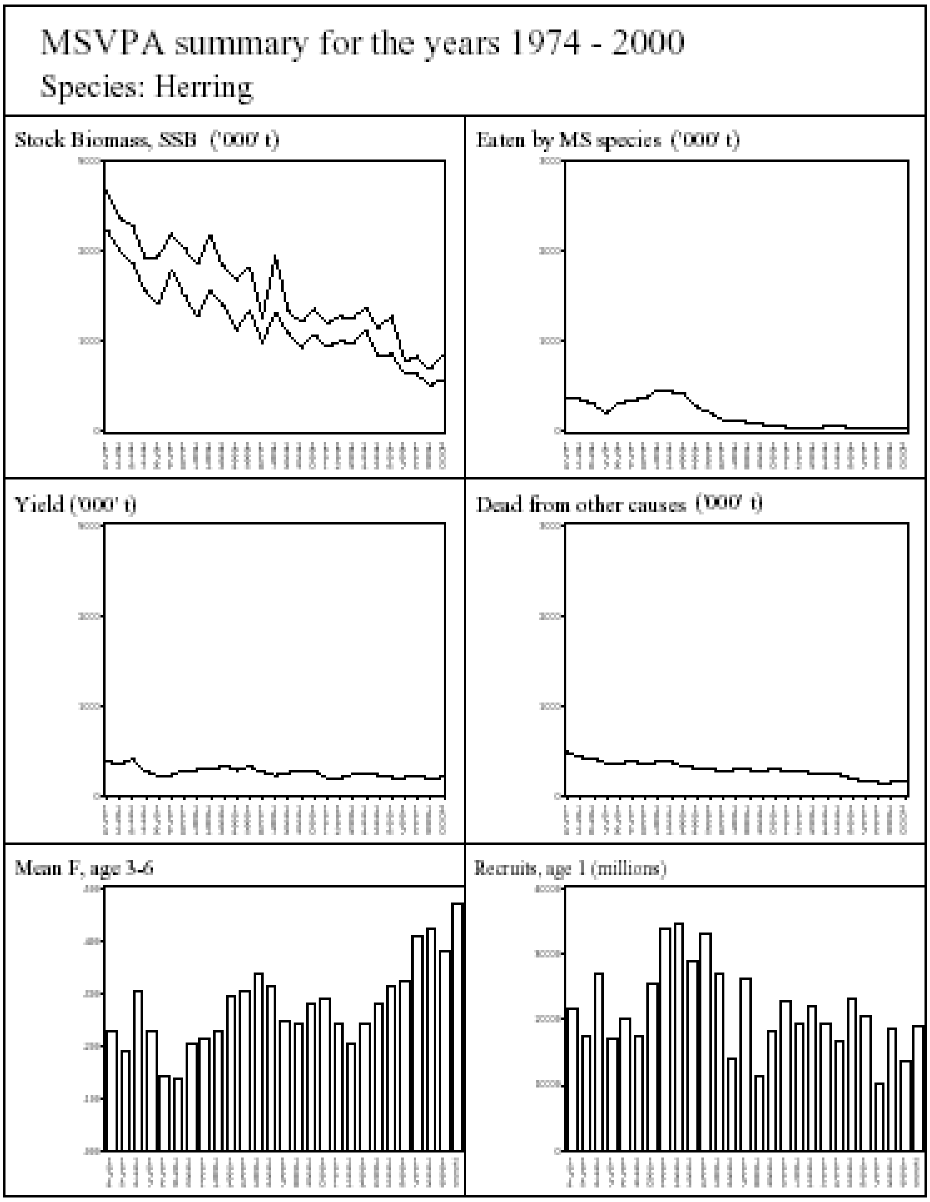


Fig. 5.2.29. Results of the MSVPA-run for herring.

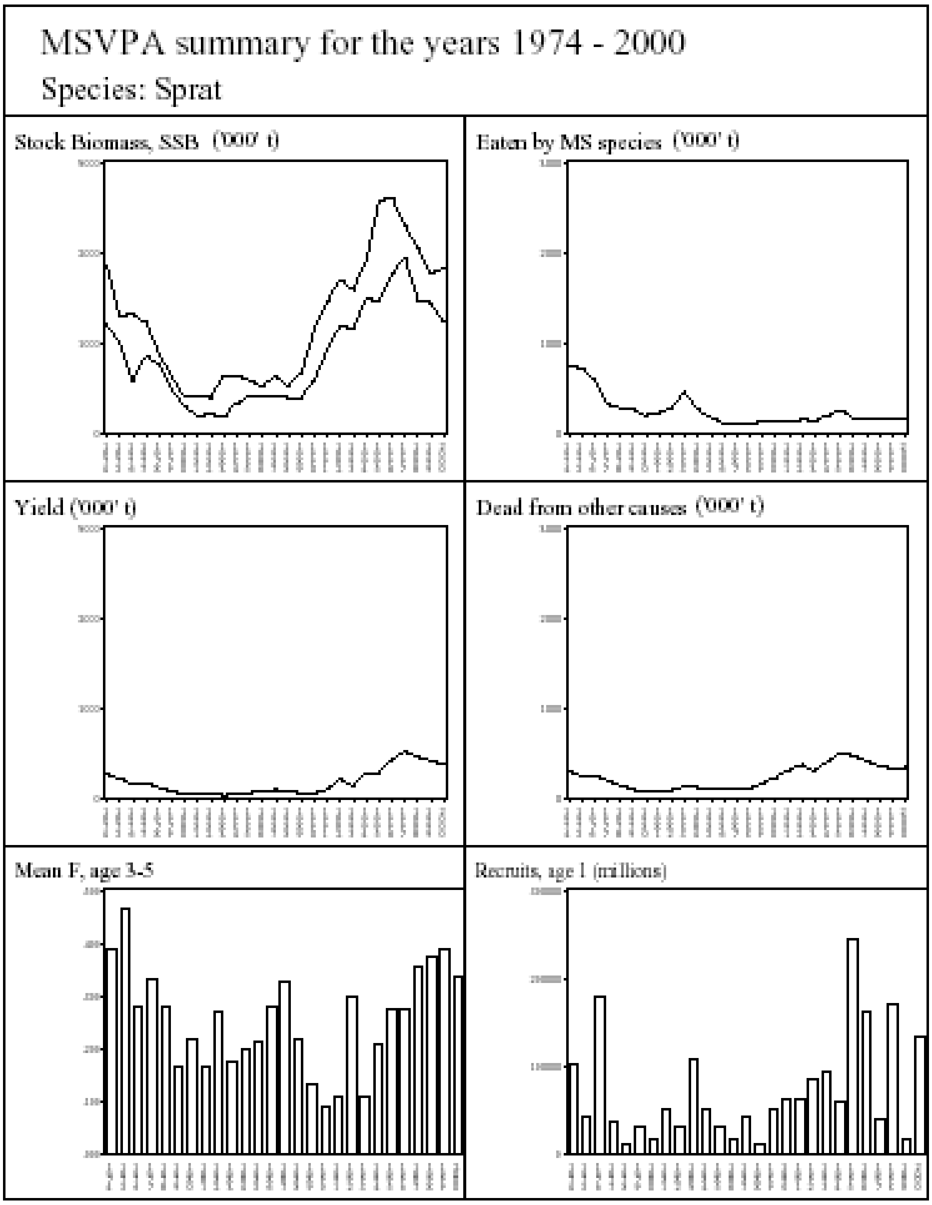


Fig. 5.2.30. Results of the MSVPA-run for sprat.

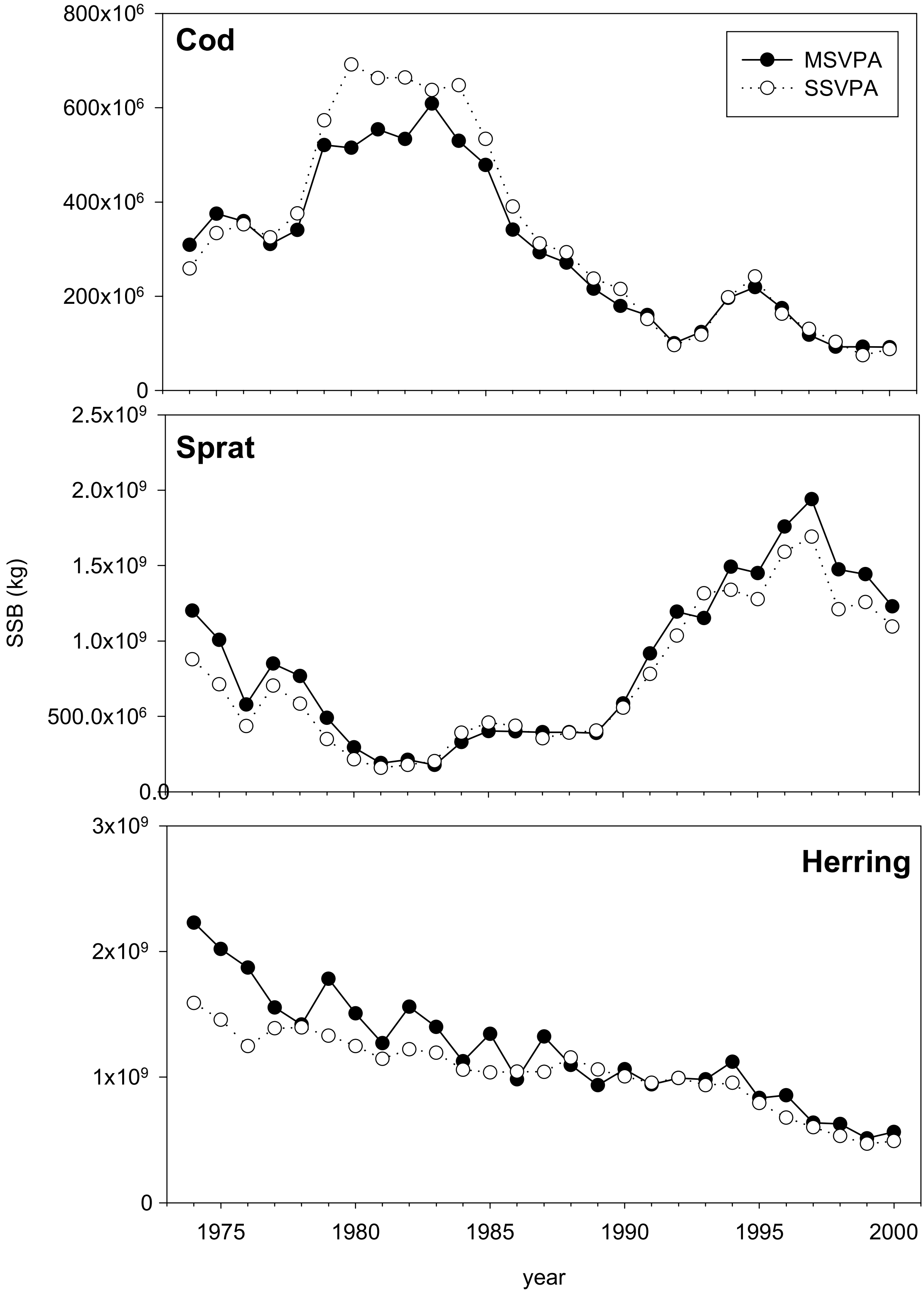


Fig. 5.2.31 Times-series of spawning stock biomass (SSB, 1st quarter) of cod, herring and sprat in the Central Baltic Sea derived from MSVPA and standard assessment (SVPA).

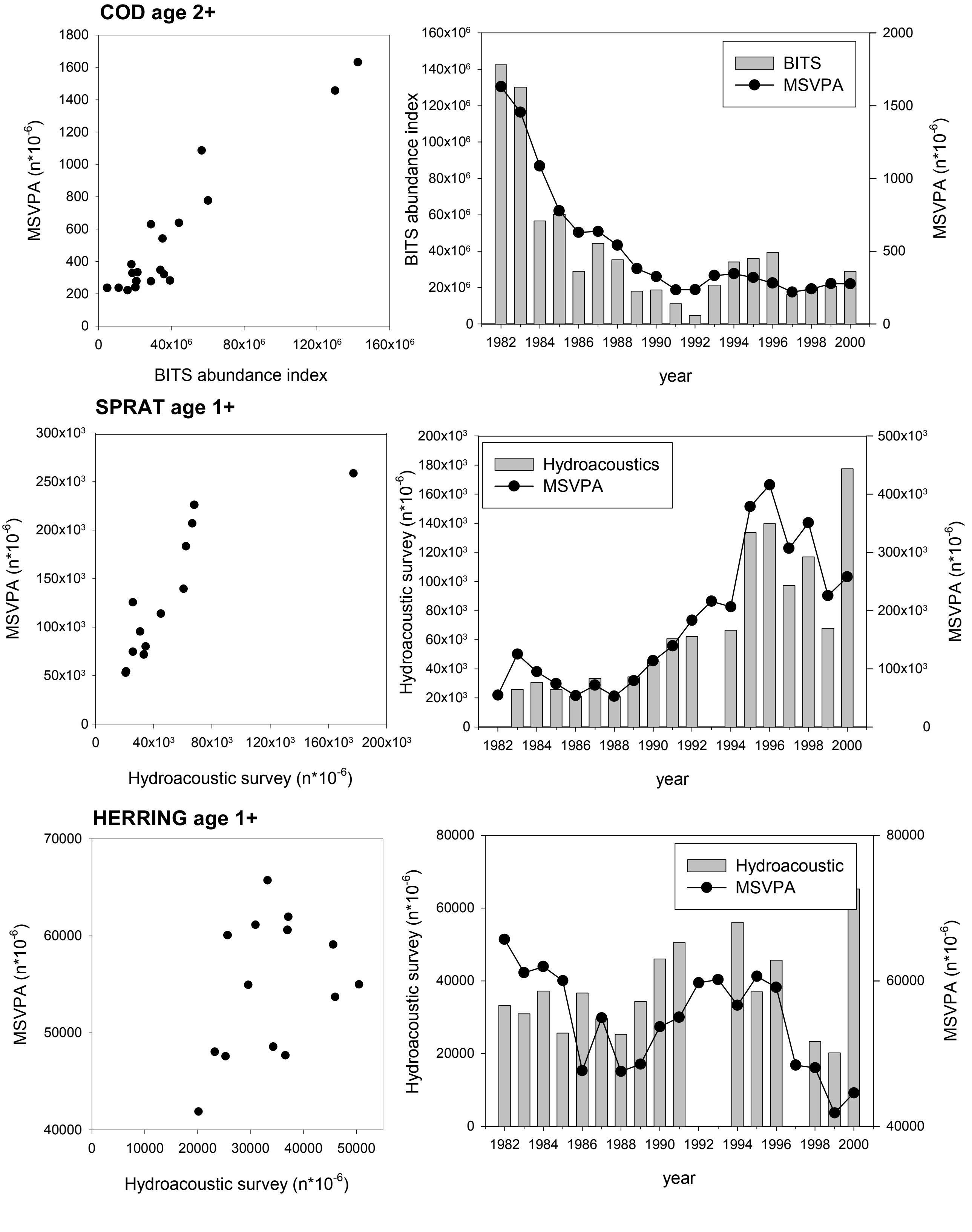


Fig. 5.2.32. Comparisons of stock sizes (1st quarter) from MSVPA for cod, herring and sprat with survey data used for tuning (cod: Baltic International Trawl Survey, BITS; herring and sprat: International Hydroacoustic Survey). Left panels: Correlations, right panels: time-series.

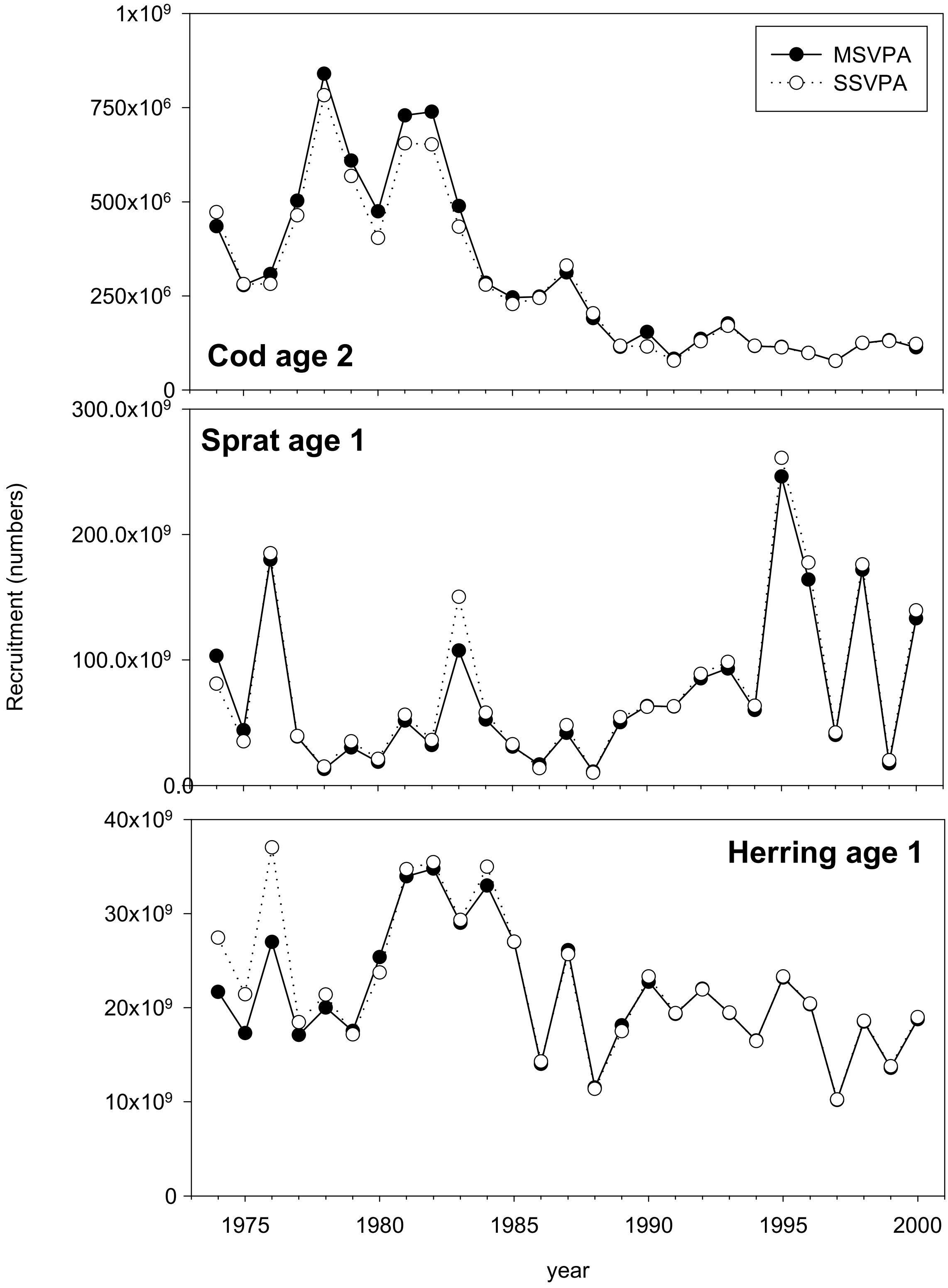


Fig. 5.2.33. Time-series of recruitment estimates (1st quarter) of cod, herring and sprat in the Central Baltic Sea derived from MSVPA and standard assessment (SSVPA).

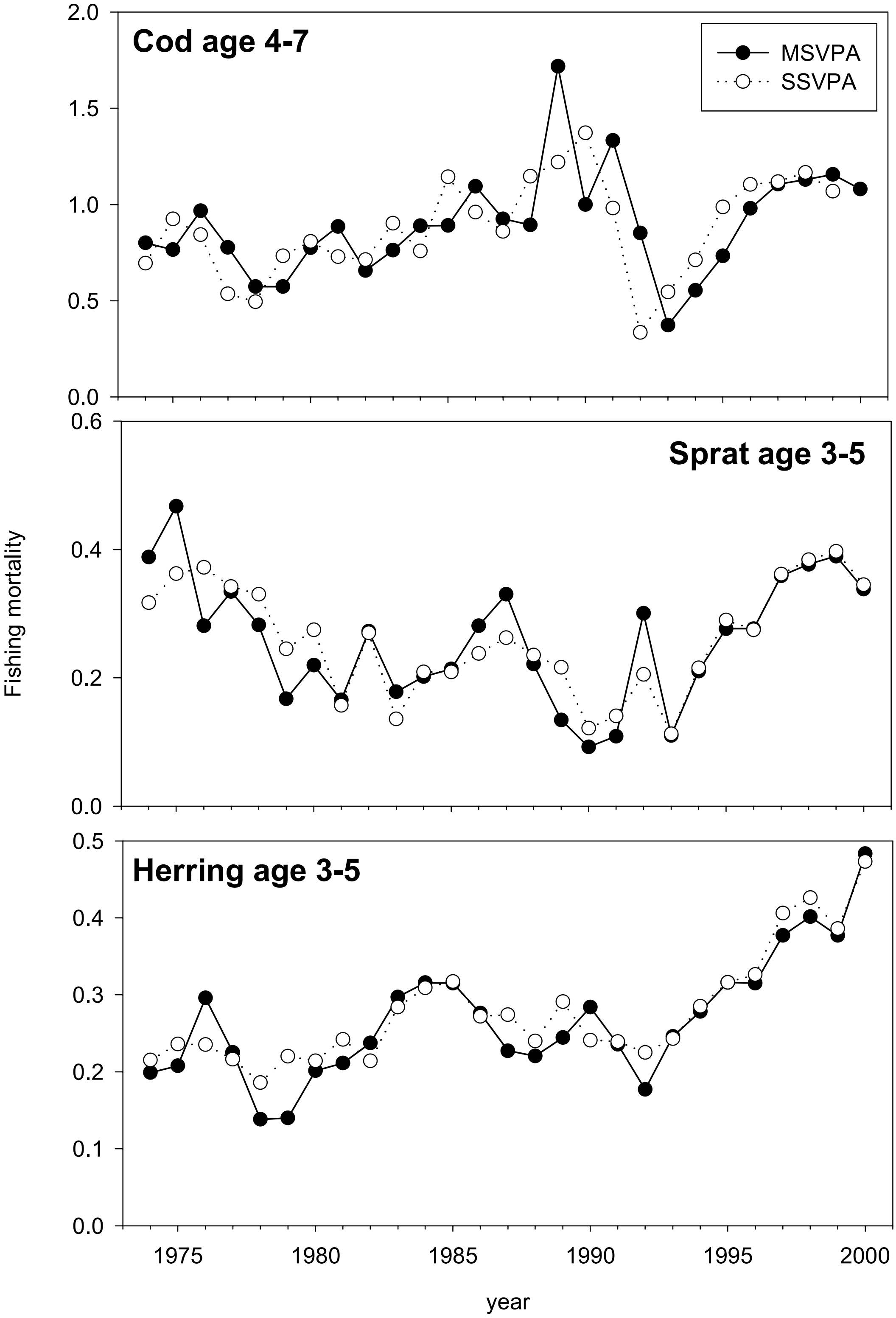


Fig. 5.2.34. Time-series of annual fishing mortalities of cod, herring and sprat in the Central Baltic Sea derived from MSVPA and standard assessment (SSVPA).

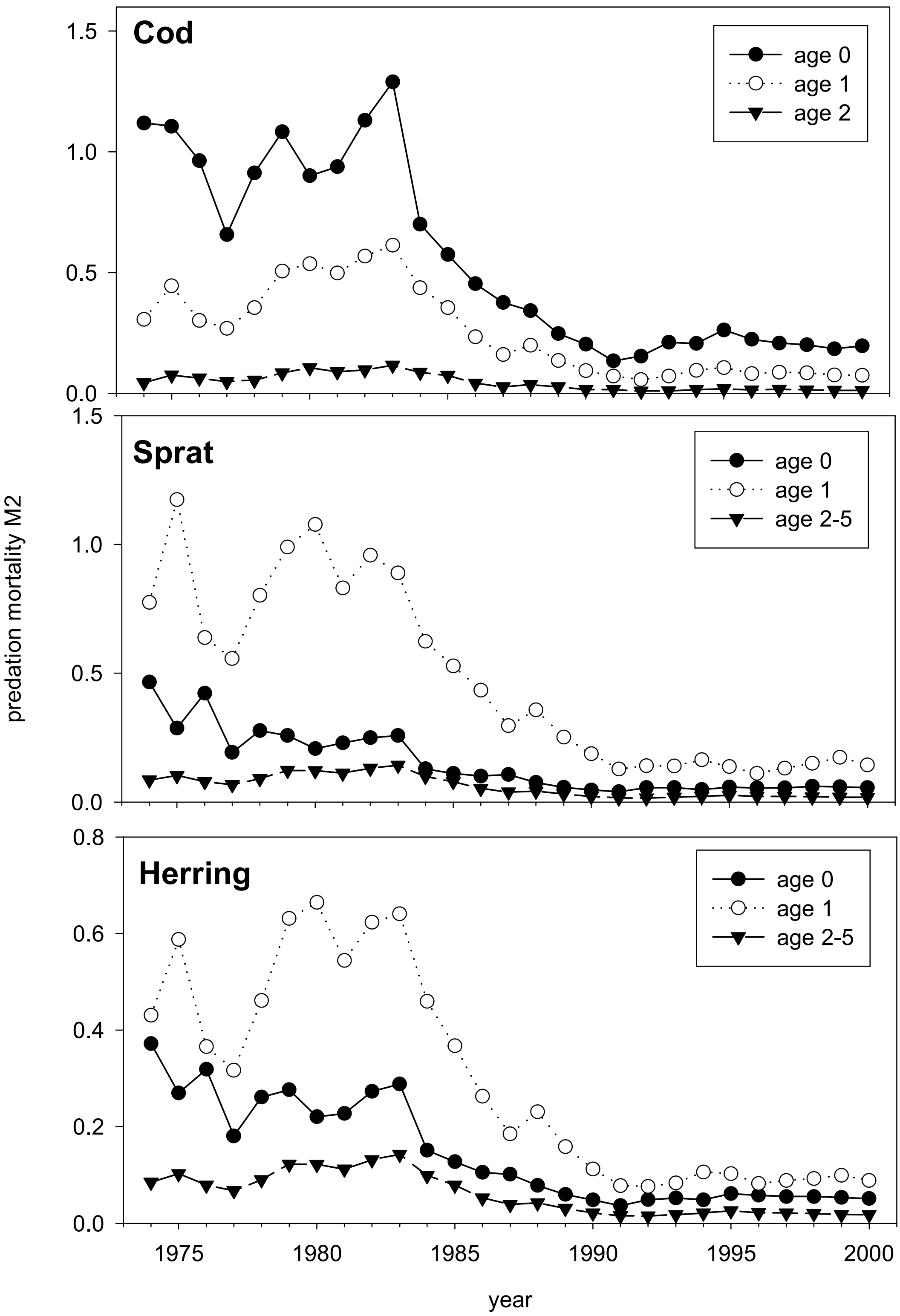


Fig. 5.2.35. Time-series of annual predation mortalities of cod, sprat and herring in the Central Baltic Sea derived from MSVPA.

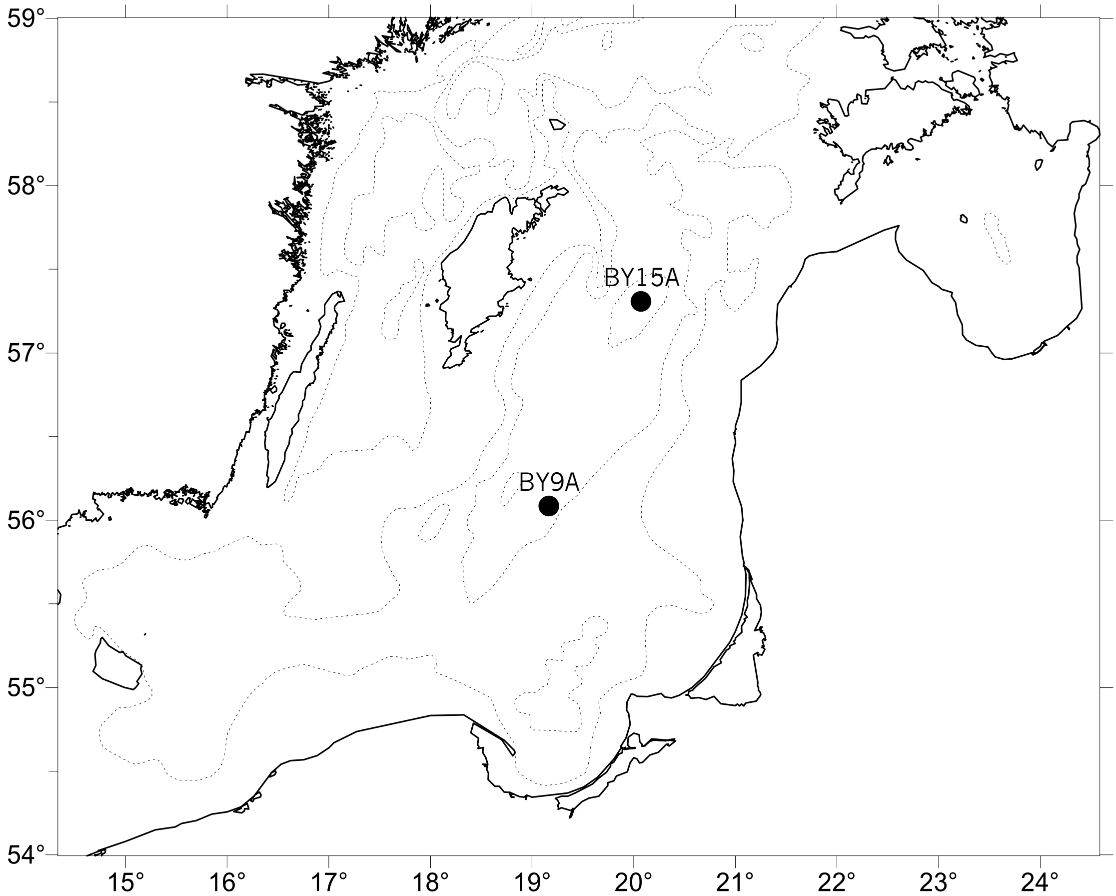


Fig. 5.2.36. Hydrography stations in the Gotland Deep (stations BY9A and BY15A).

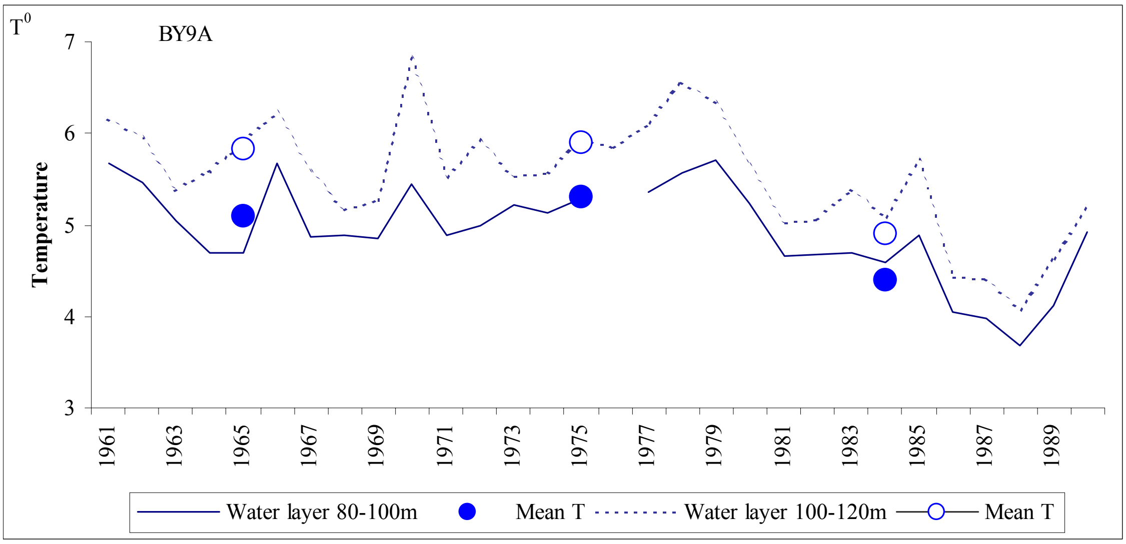


Fig. 5.2.37. Temperature fluctuations at different water layers in the Gotland Deep (station BY9A).

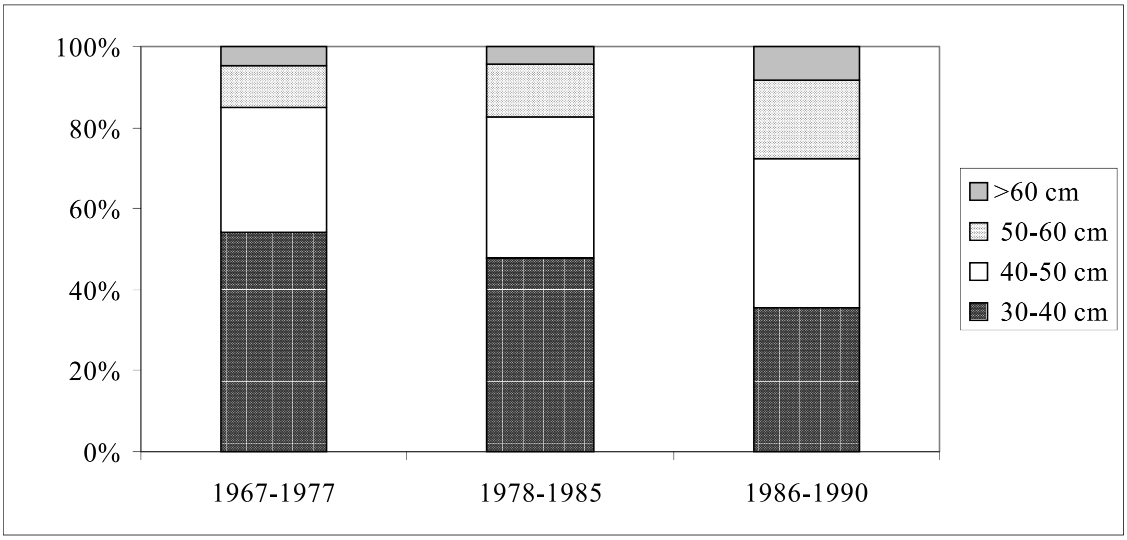


Fig. 5.2.38. Size-frequency distribution of the cod spawning stock for different periods in January.

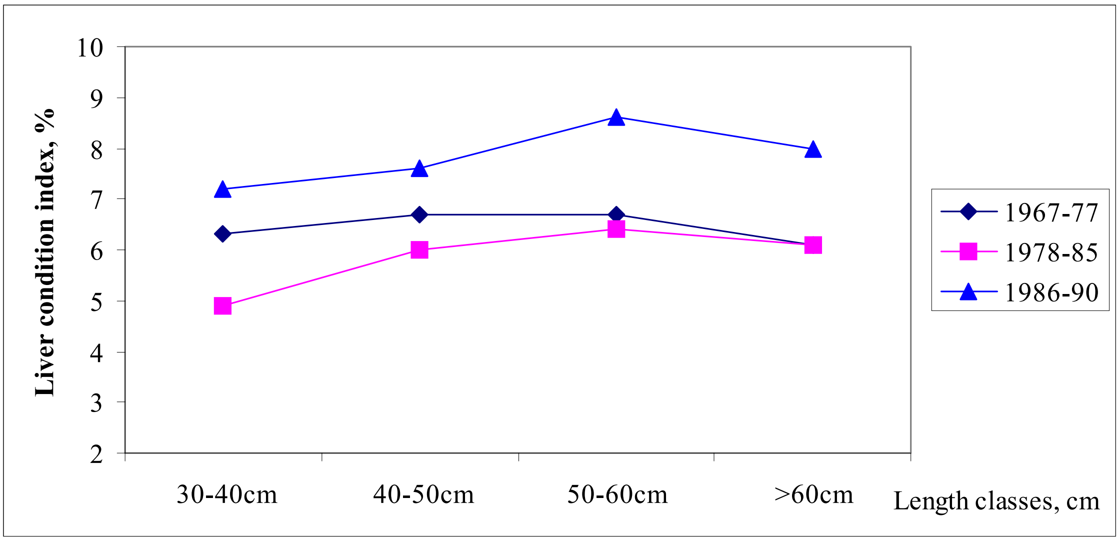
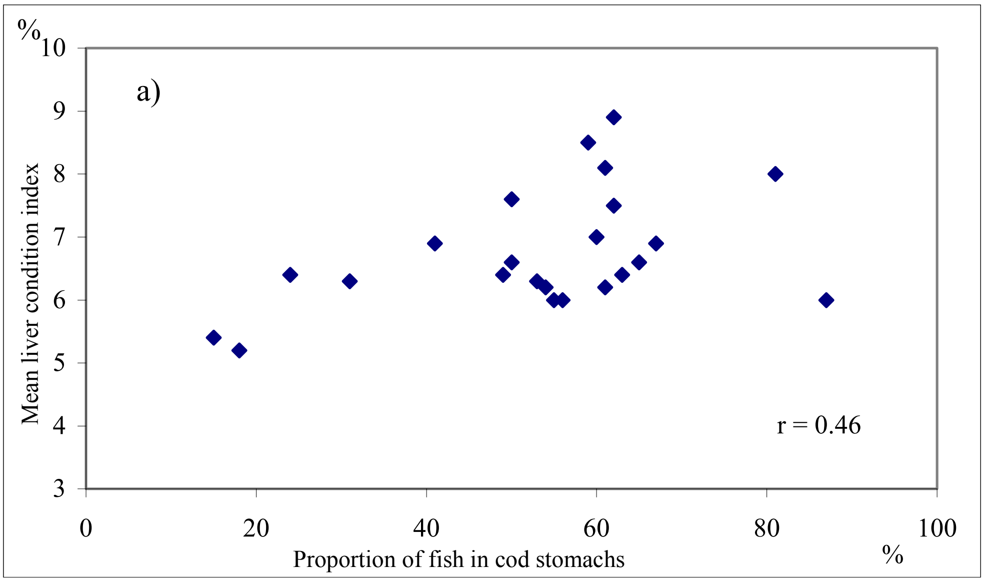


Fig. 5.2.39. Mean liver condition index per length classes of female cod for different periods in January.



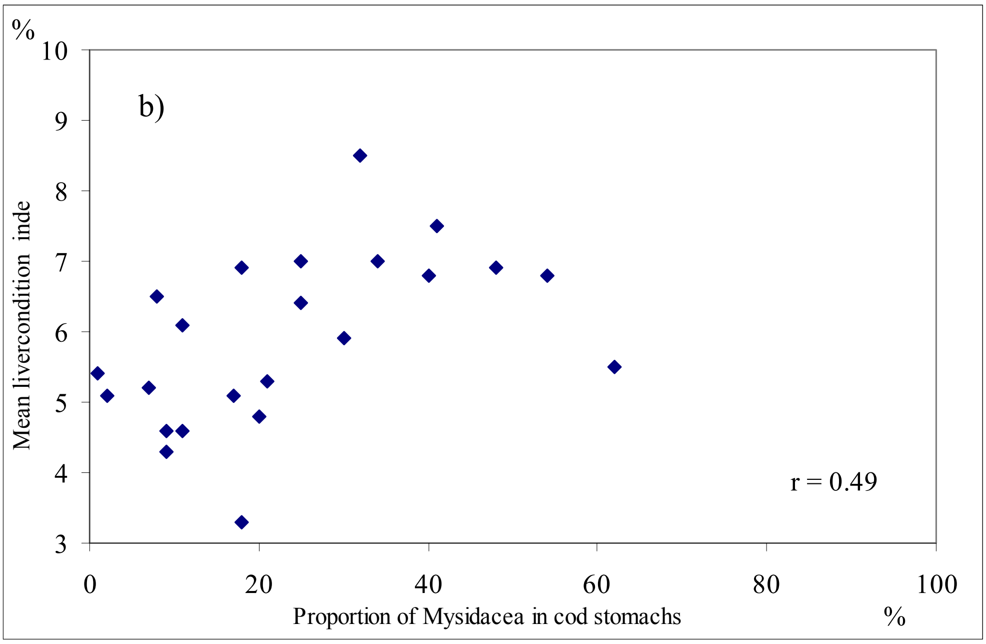
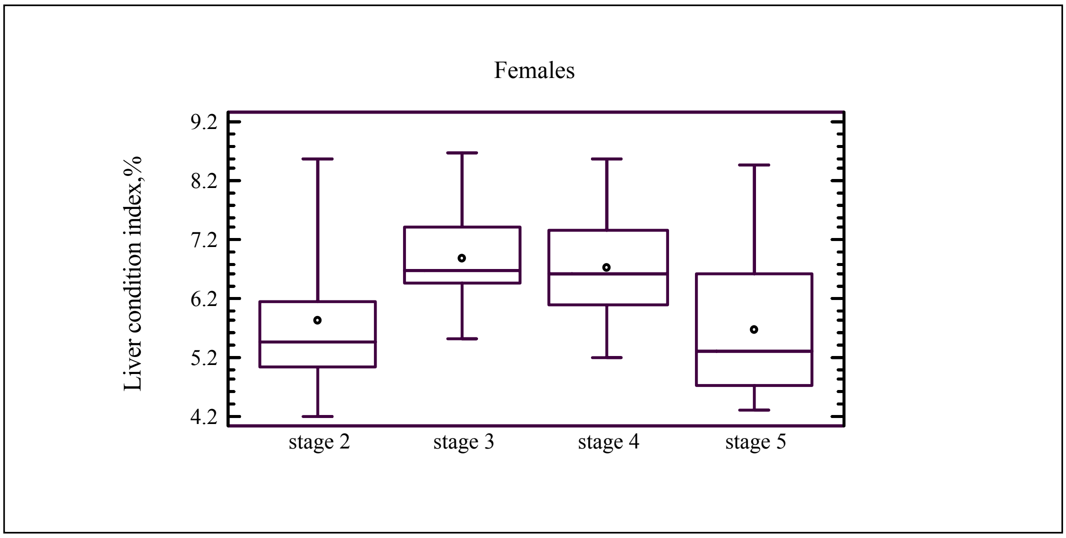


Fig. 5.2.40. Relation between mean liver condition index of female cod in January and proportion of fish food in stomachs in the autumn feeding season for length >40cm (a) and proportion of Mysidacea in stomachs for length 30-40cm (b).



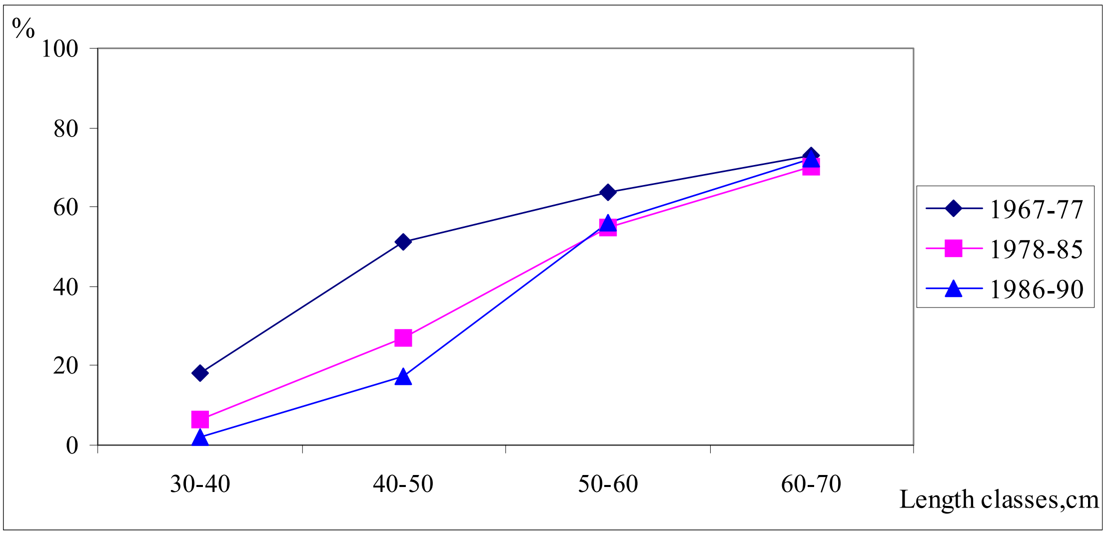


Fig. 5.2.41. Proportion of maturing (stage 3, 4) females for different periods in January.

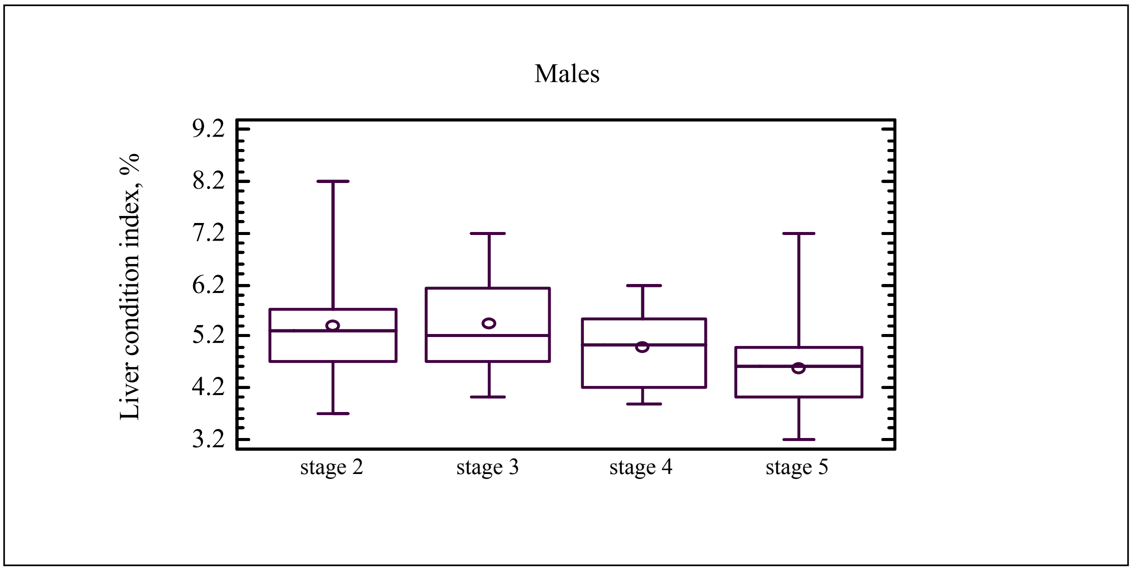
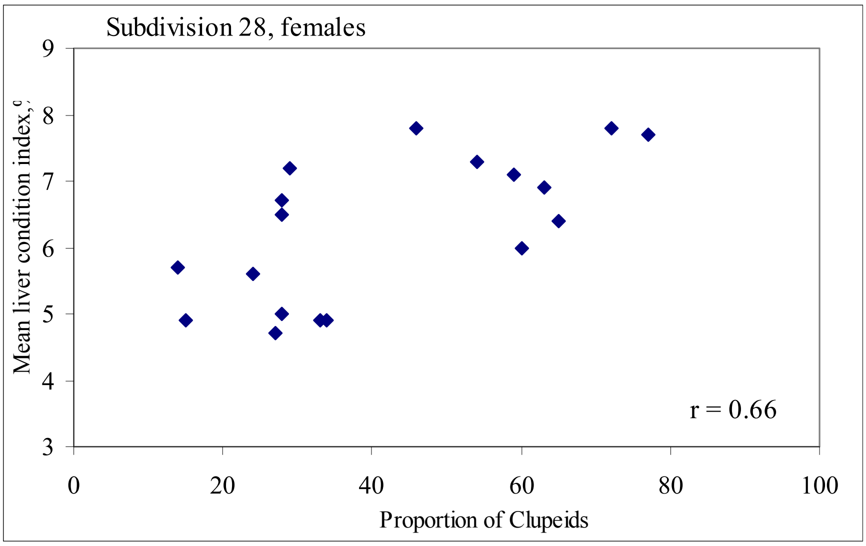


Fig. 5.2.42. Box-Whisker plots of mean liver condition index of cod per maturity stage 2 to 5 in March on the Gotland spawning grounds.



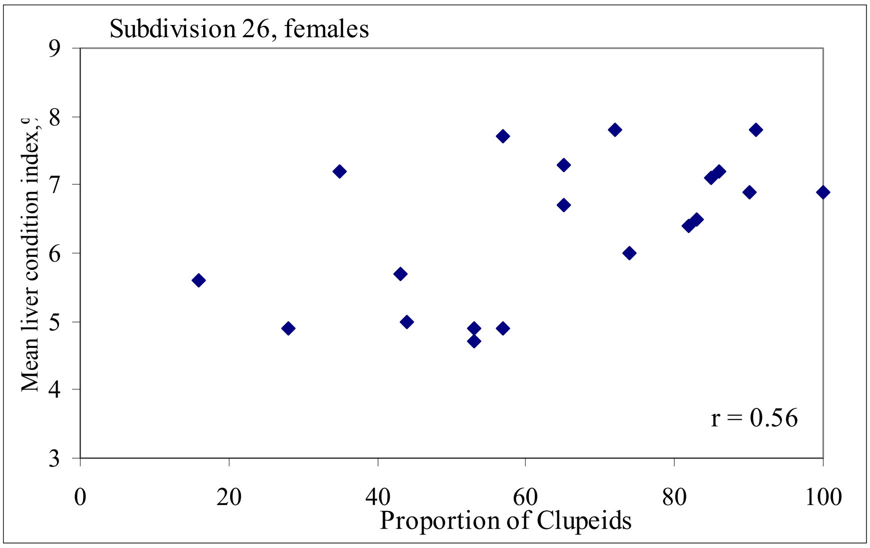
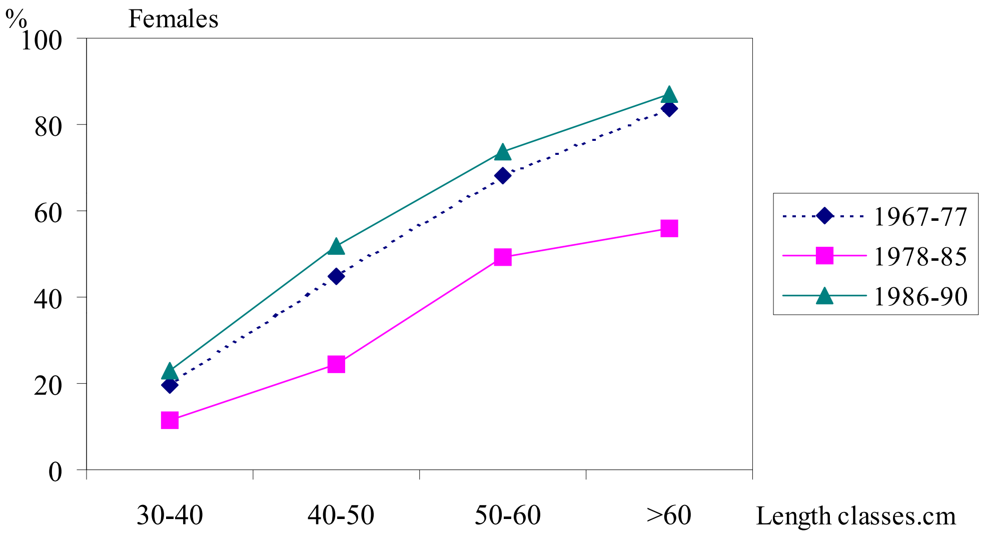


Fig. 5.2.43. Relationship between mean liver condition index of females in maturing stage 4 in April and % of clupeids in stomachs of cod in subdivisions 28 and 26 in March-April of 1967-1990.



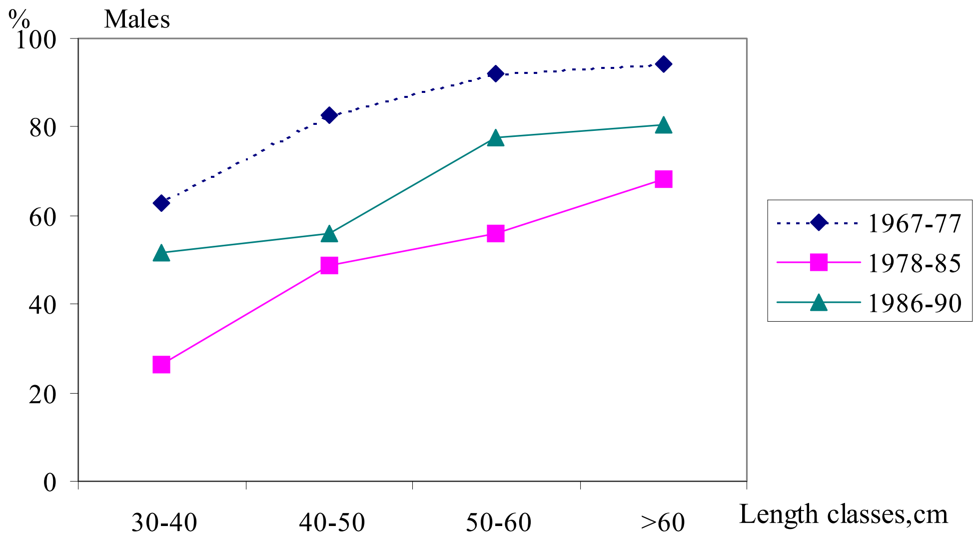


Fig. 5.2.44. Proportion of maturing (stage 4) and spawning (stage 5) female and male cod in for different periods in March in relation to length classes.

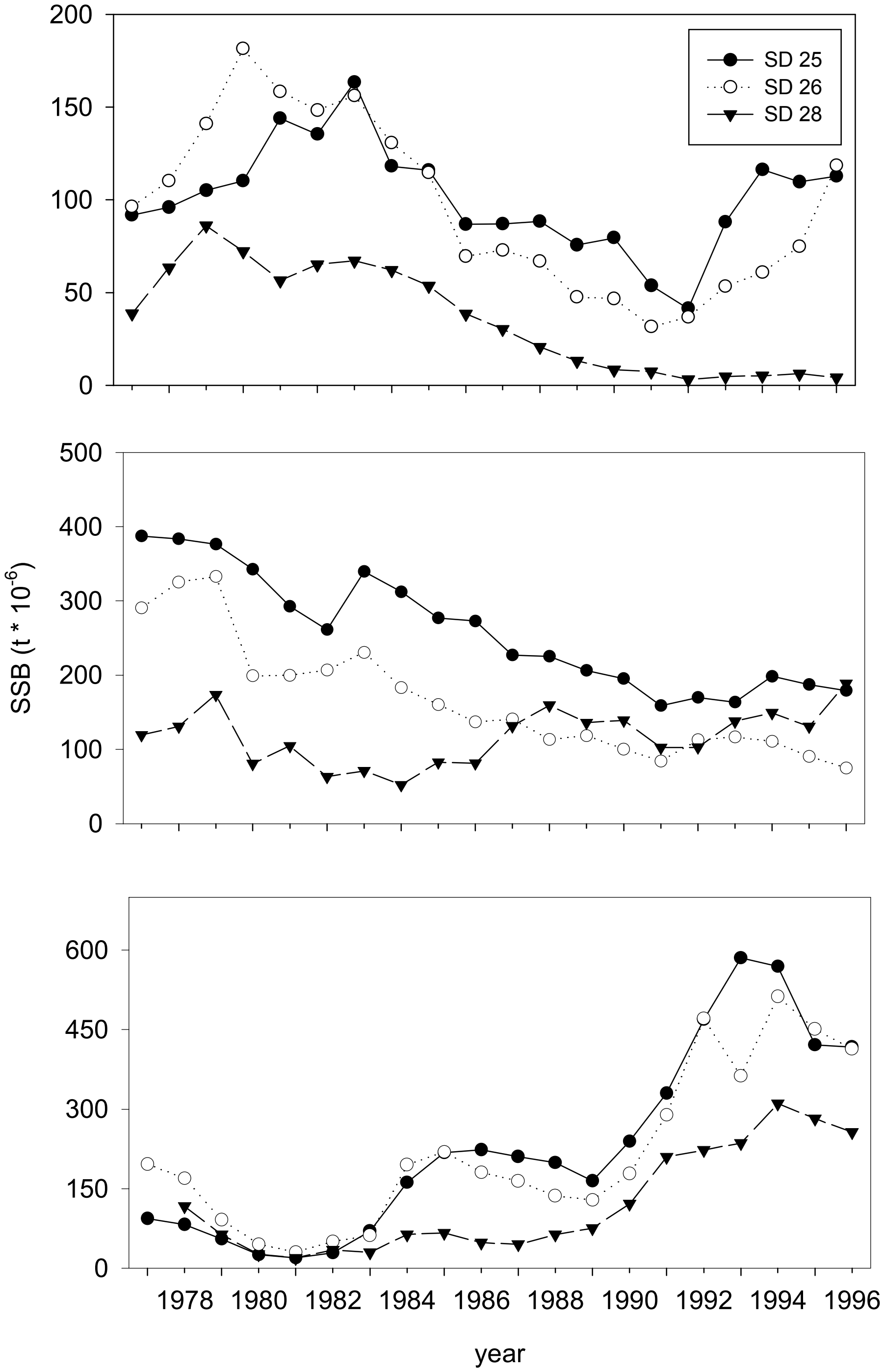


Fig. 5.3.1. Spawning stock biomass of cod (upper panel), herring (middle panel) and sprat (lower panel) in the different Sub-divisions (SD) of the Central Baltic Sea.

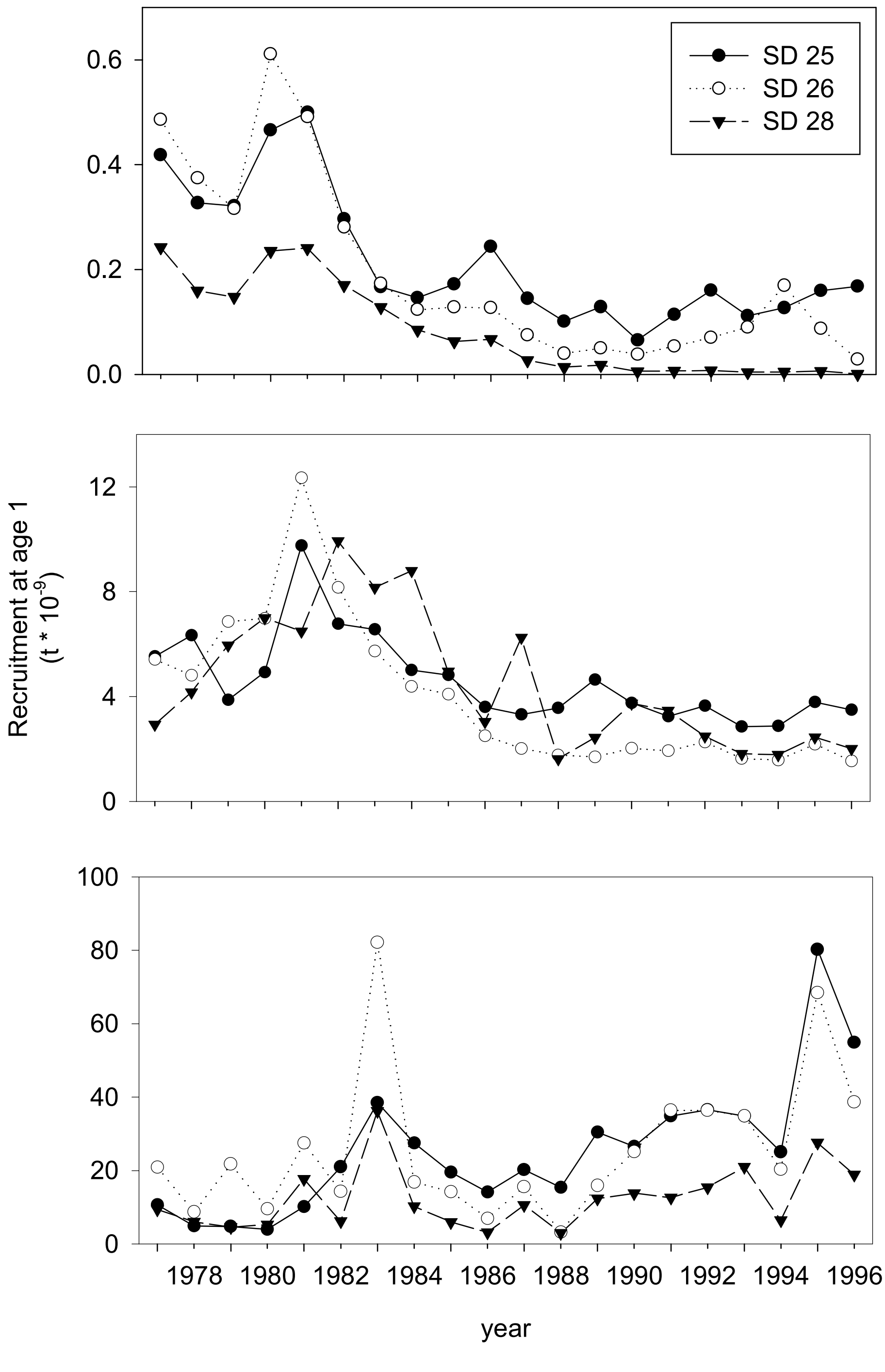


Fig. 5.3.2. Recruitment at age 1 of cod (upper panel), herring (middle panel) and sprat (lower panel) in the different Sub-divisions (SD) of the Central Baltic Sea.

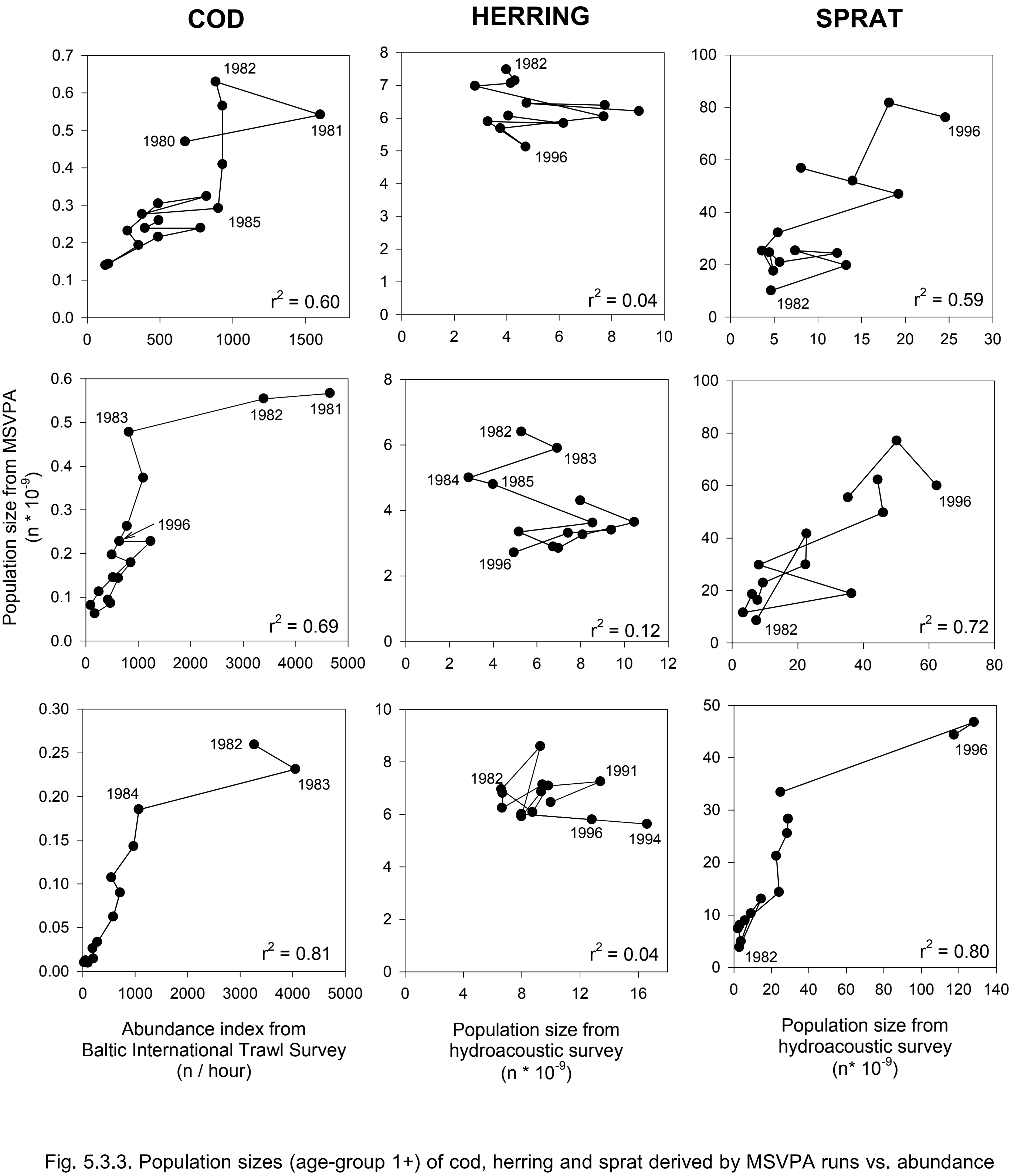


Fig. 5.3.3. Population sizes (age-group 1+) of cod, herring and sprat derived by MSVPA runs vs. abundance indices from tuning fleets (upper row – Sub-division 25; middle row – Sub-division 26; lower row – Sub-division 28; r^2 – correlation coefficient).

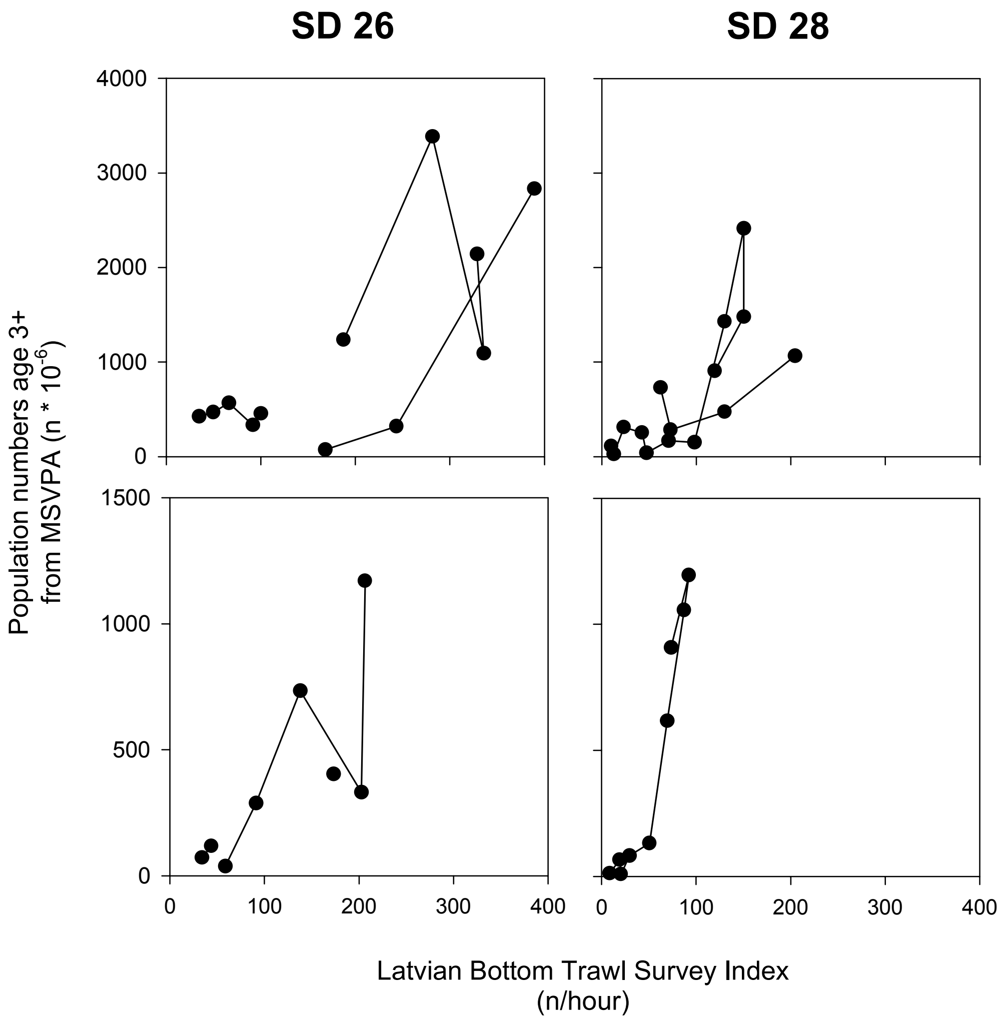


Fig. 5.3.4. Population sizes of cod derived by MSVPA runs vs. abundance indices (age-group 3+) from the Latvian Bottom Trawl Survey in Sub-divisions (SD) 26 and 28 (upper row – January; lower row – November/December).

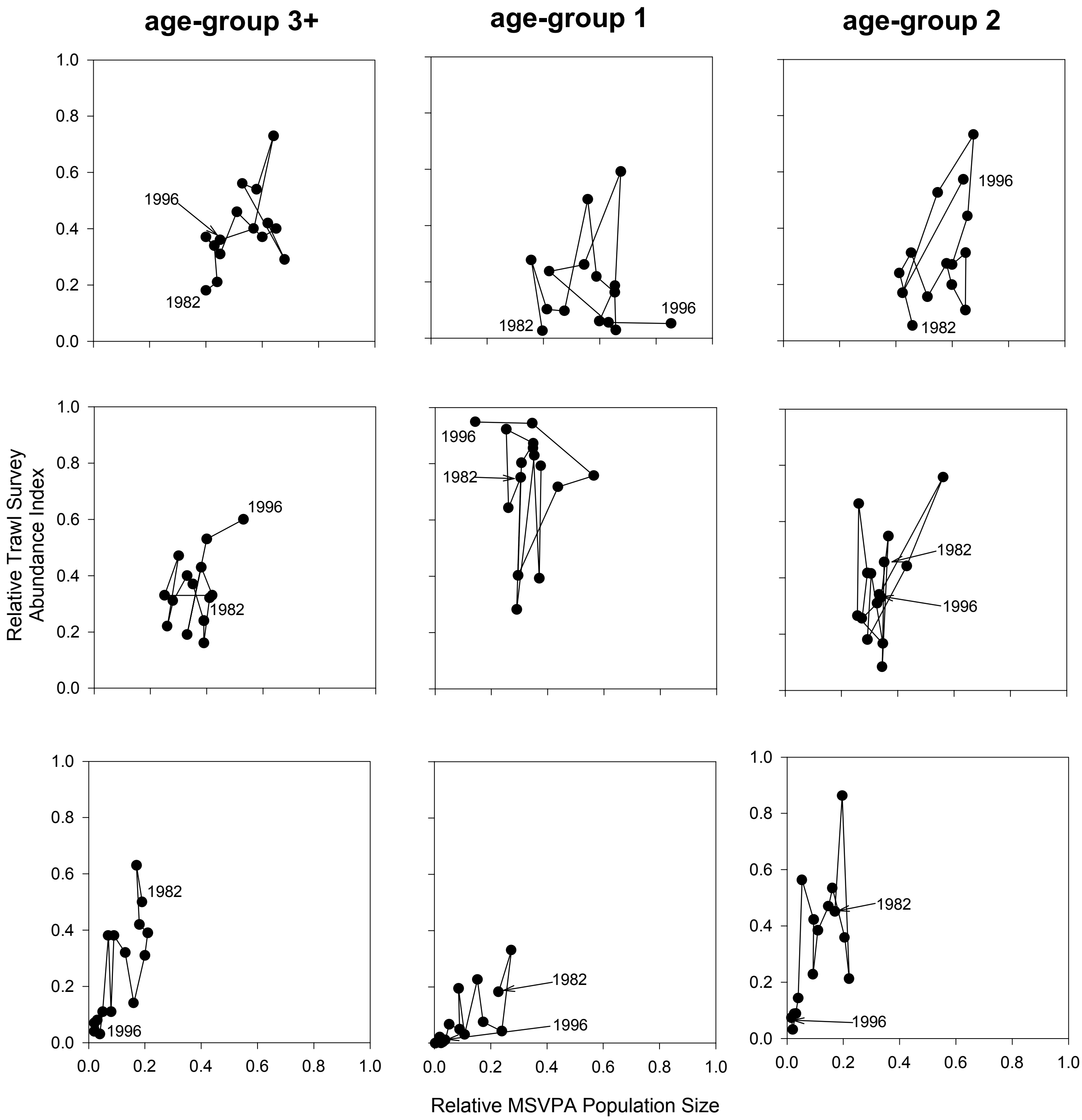


Fig. 5.3.5. Relative distributions of cod abundance indices (age groups 3+, 1 and 2) from the Baltic International Trawl Survey vs. corresponding proportions of abundance estimated by MSVPA runs (upper row – Sub-division 25; middle row – Sub-division 26; lower row – Sub-division 28).

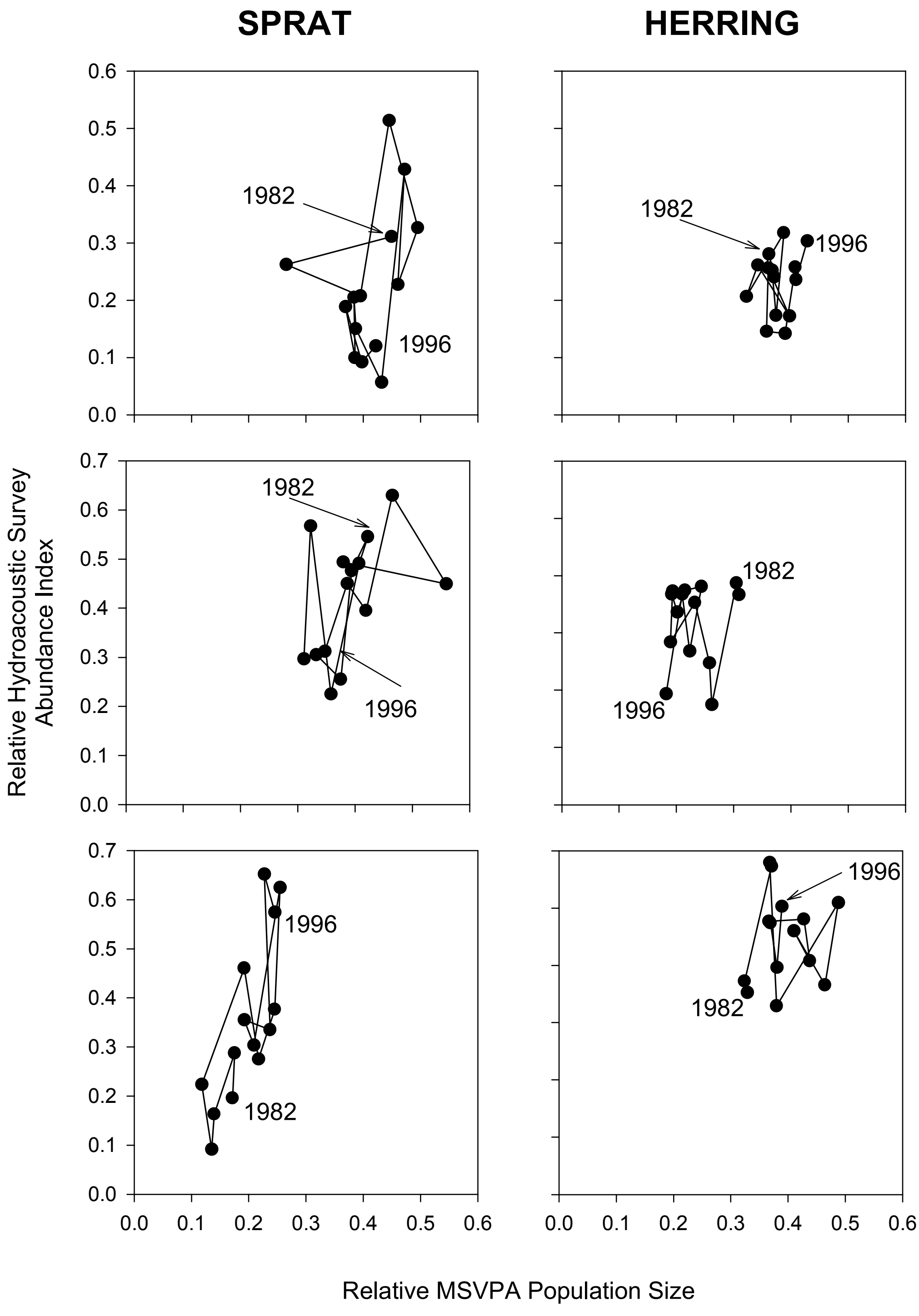


Fig. 5.3.6. Relative distributions of sprat and herring abundance indices (age group 1+) from the International Hydroacoustic Survey vs. corresponding proportions of abundance estimates derived by MSVPA runs (upper row – Sub-division 25; middle row – Sub-division 26; lower row – Sub-division 28).

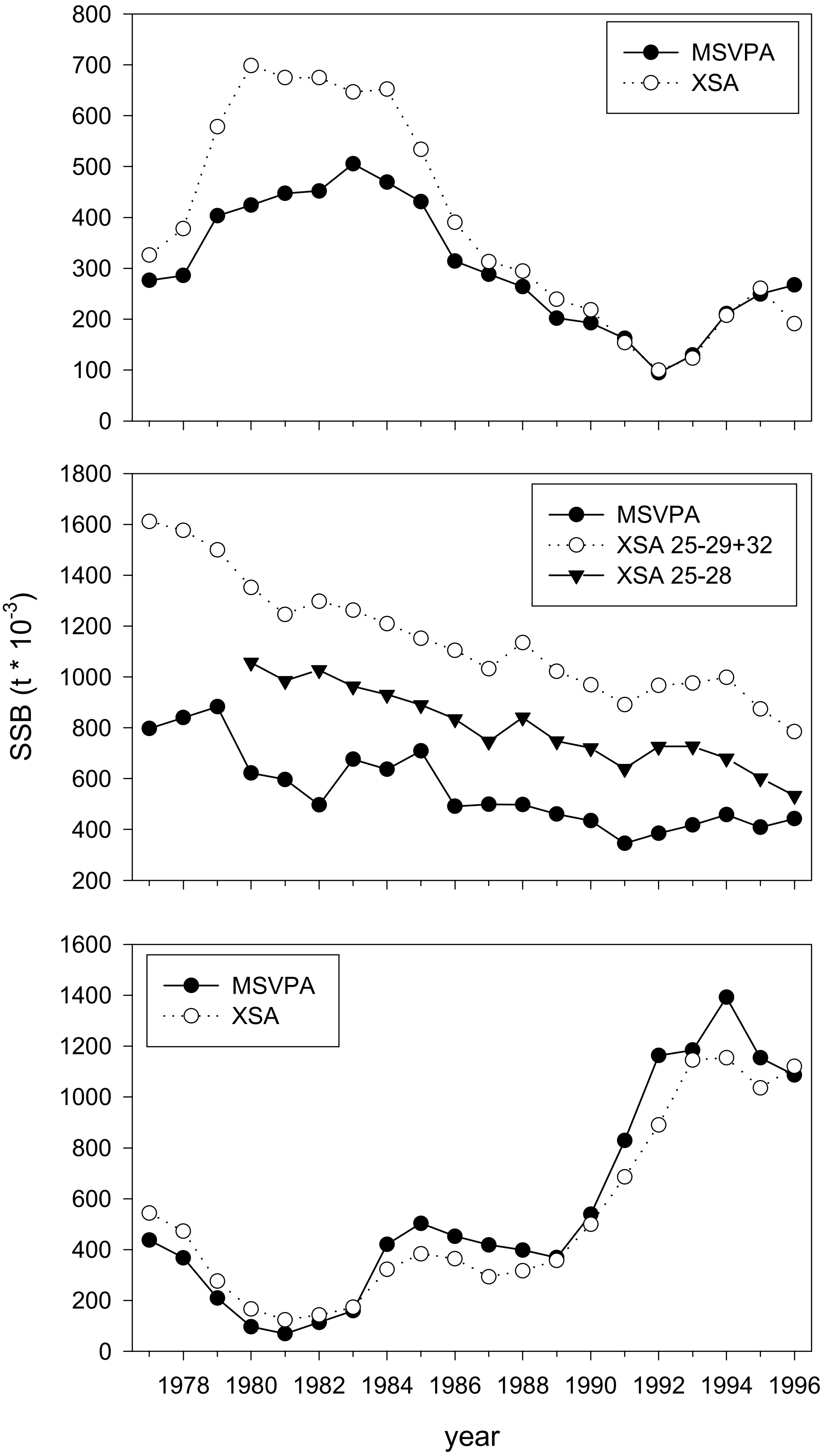


Fig. 5.3.7. Spawning stock biomass of cod (upper panel), herring (middle panel) and sprat (lower panel) derived by MSVPA runs and singlespecies assessments (XSA); detailed description of assessment units in the text.

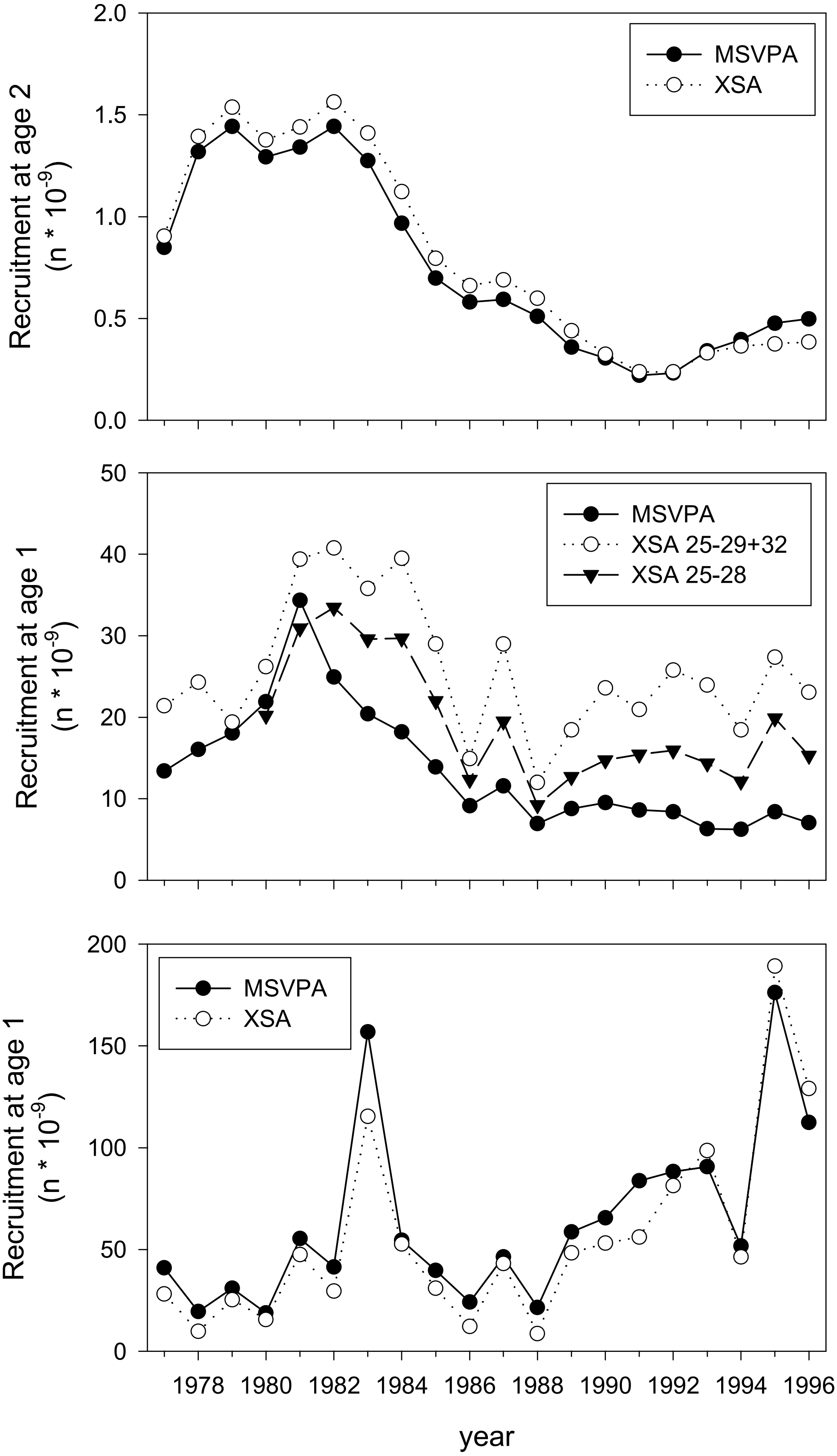


Fig. 5.3.8. Recruitment of cod (upper panel), herring (middle panel) and sprat (lower panel) derived by MSVPA runs and singlespecies assessments (XSA); detailed description of assessment units in the text.

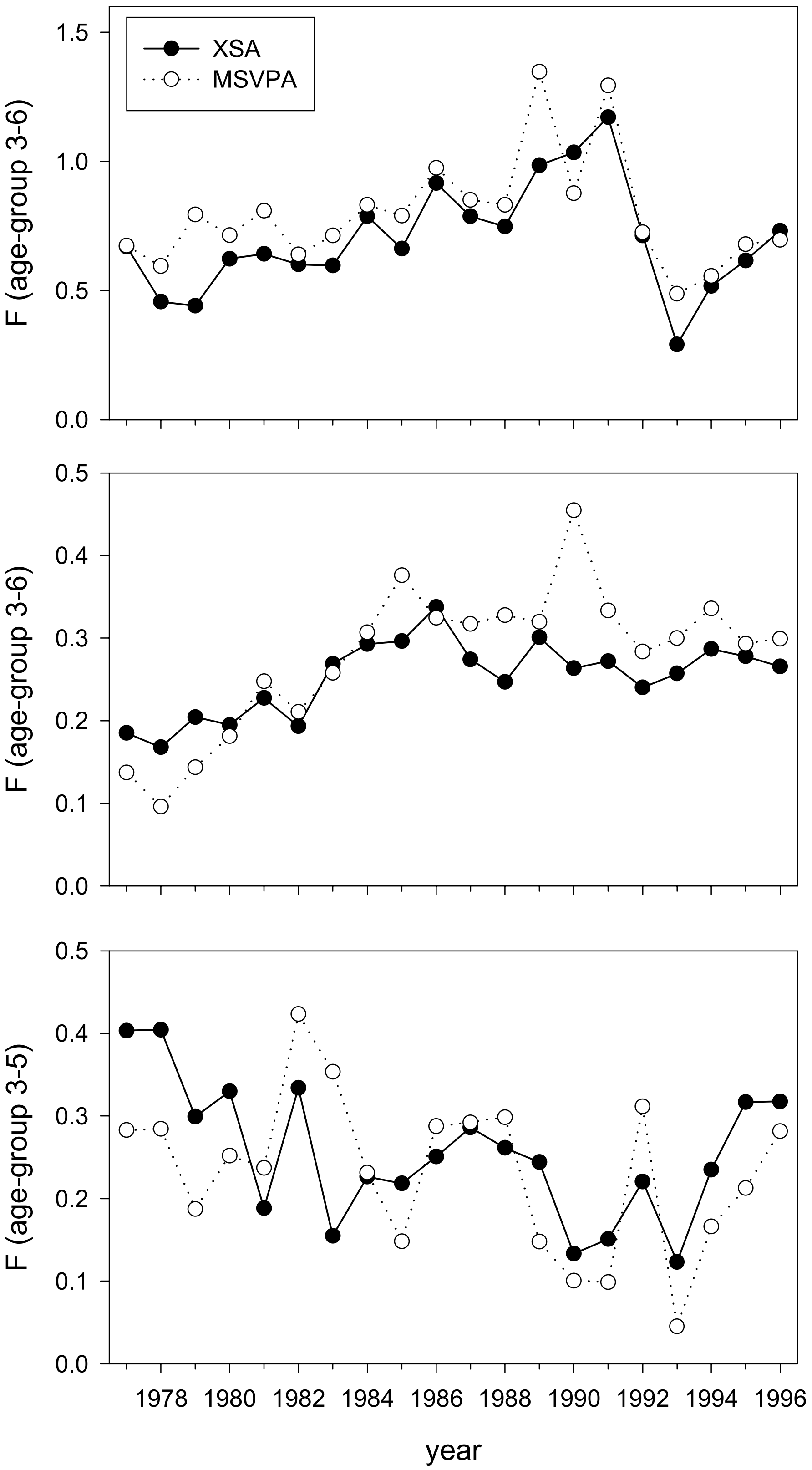


Fig. 5.3.9. Fishing mortality rates (F) of cod (upper panel), herring (middle panel) and sprat (lower panel) derived by MSVPA runs and singlespecies assessments (XSA); detailed description of assessment units in the text.

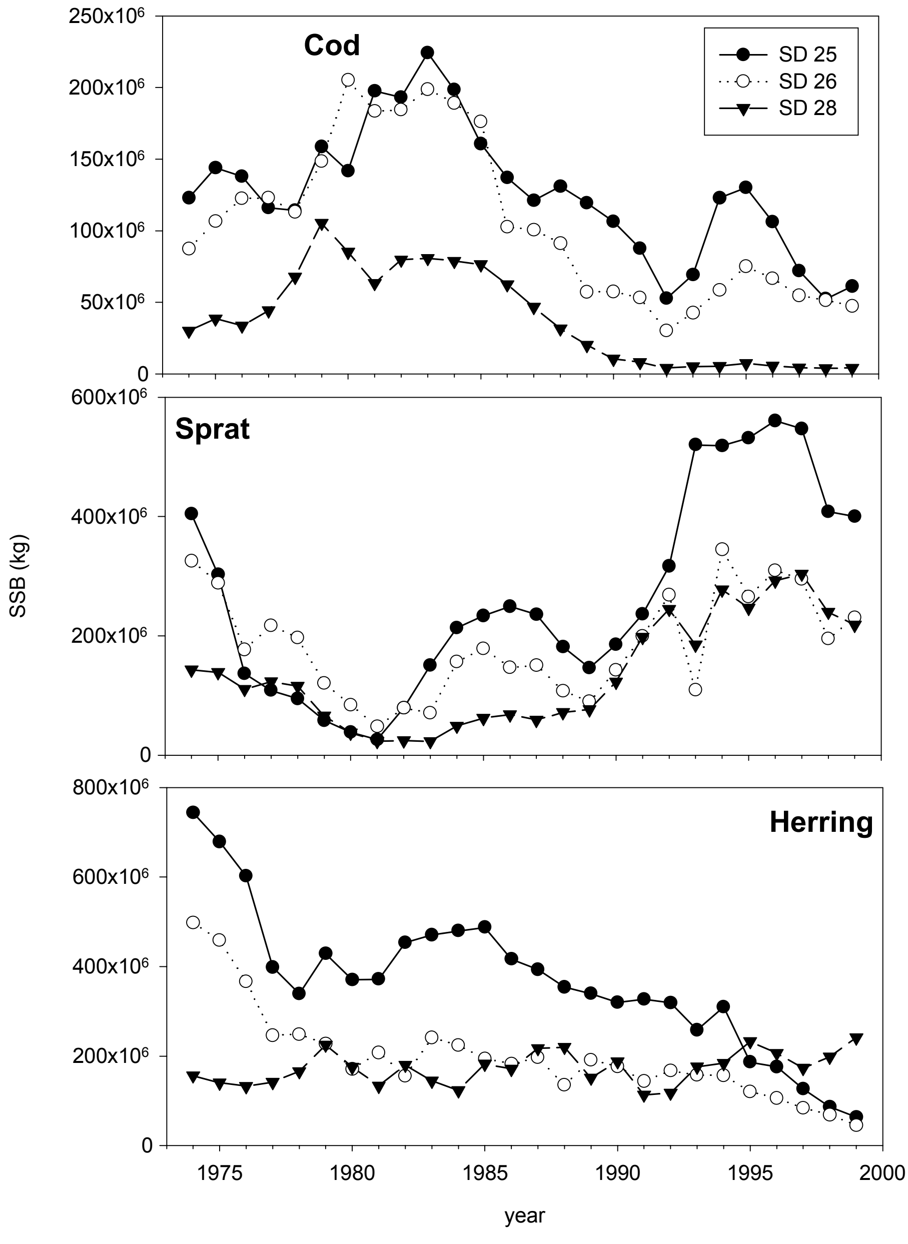


Fig. 5.3.10. Time-series of spawning stock biomass (SSB, 1st quarter) of cod, sprat and herring in the different Sub-divisions (SD) derived from area-disaggregated MSVPA.

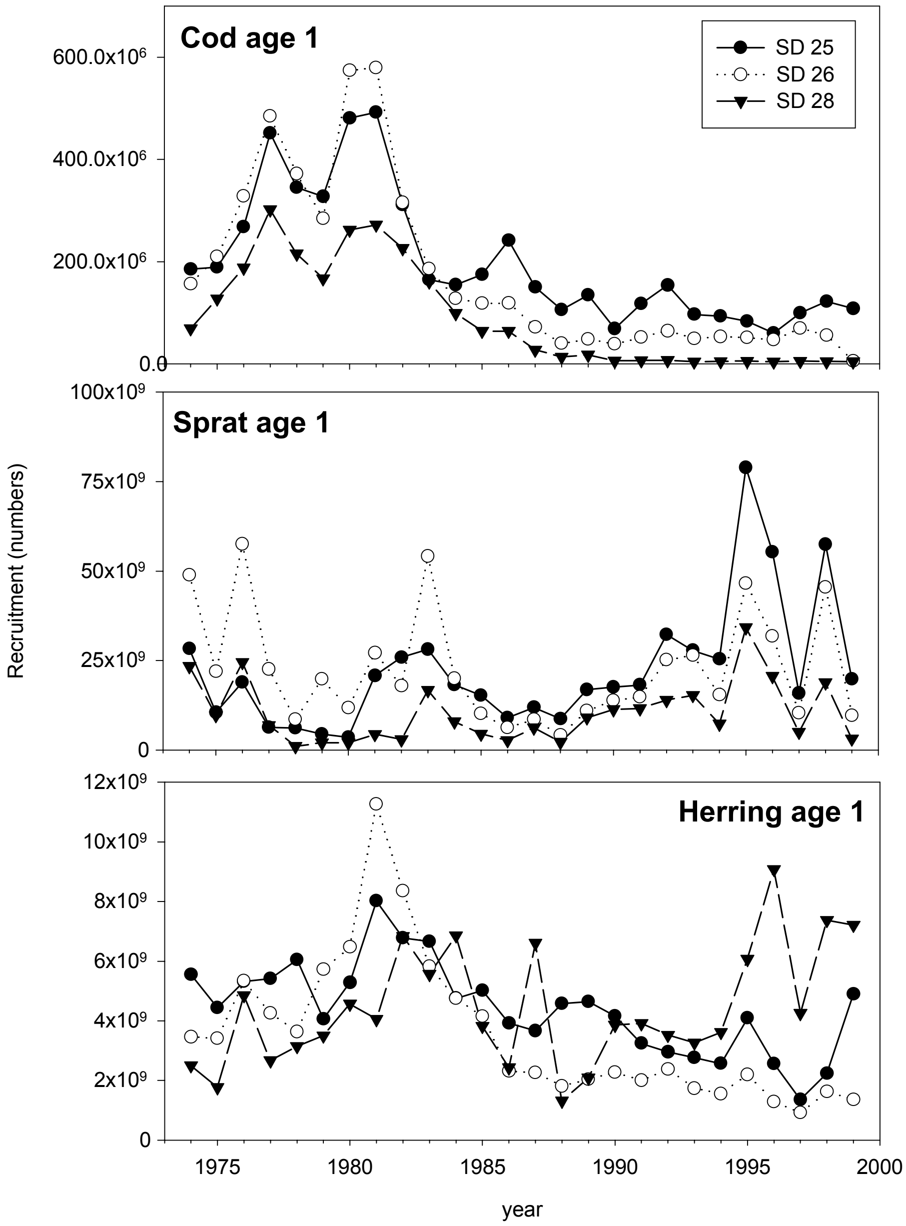


Fig. 5.3.11. Time-series of recruitment estimates (1st quarter) of cod, sprat and herring in the different Sub-divisions (SD) derived from area-disaggregated MSVPA

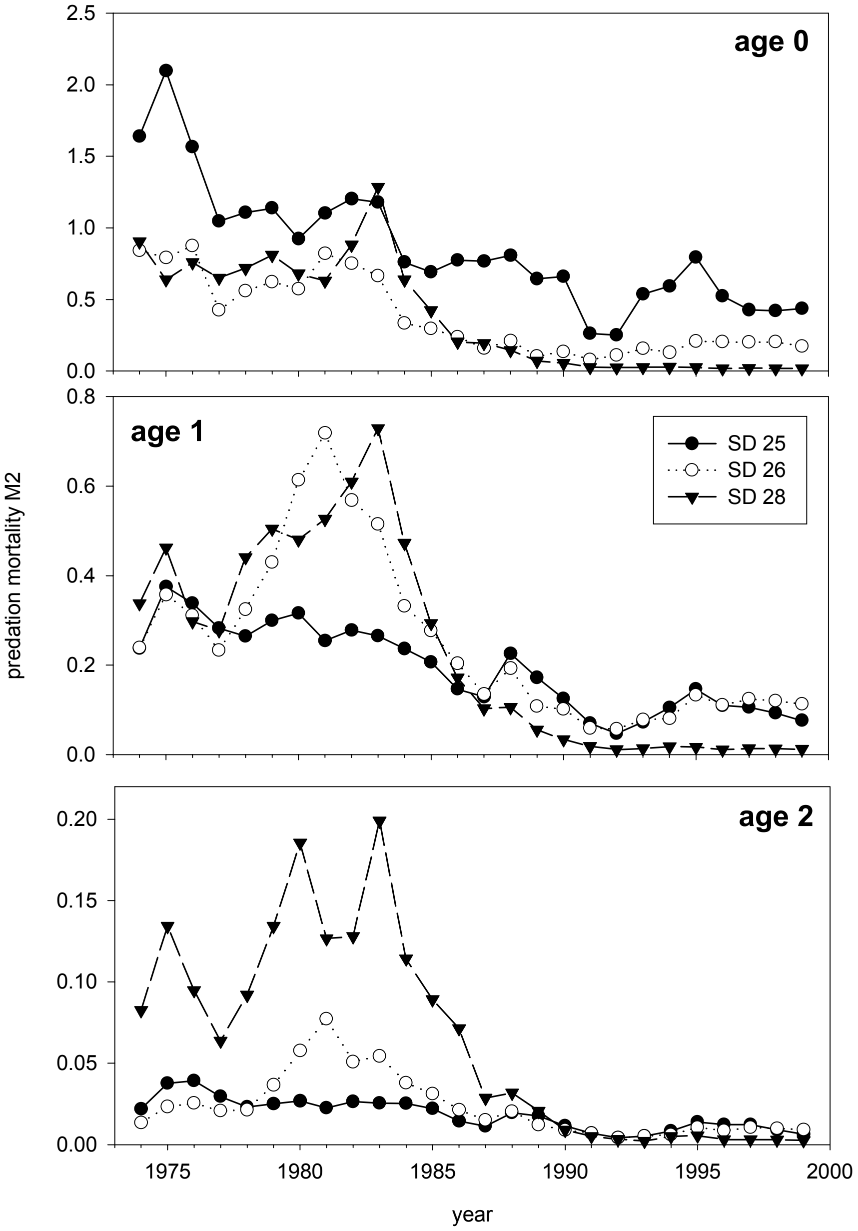


Fig. 5.3.12. Time-series of annual predation mortalities of cod in the different Sub-divisions (SD) derived from area-disaggregated MSVPA.

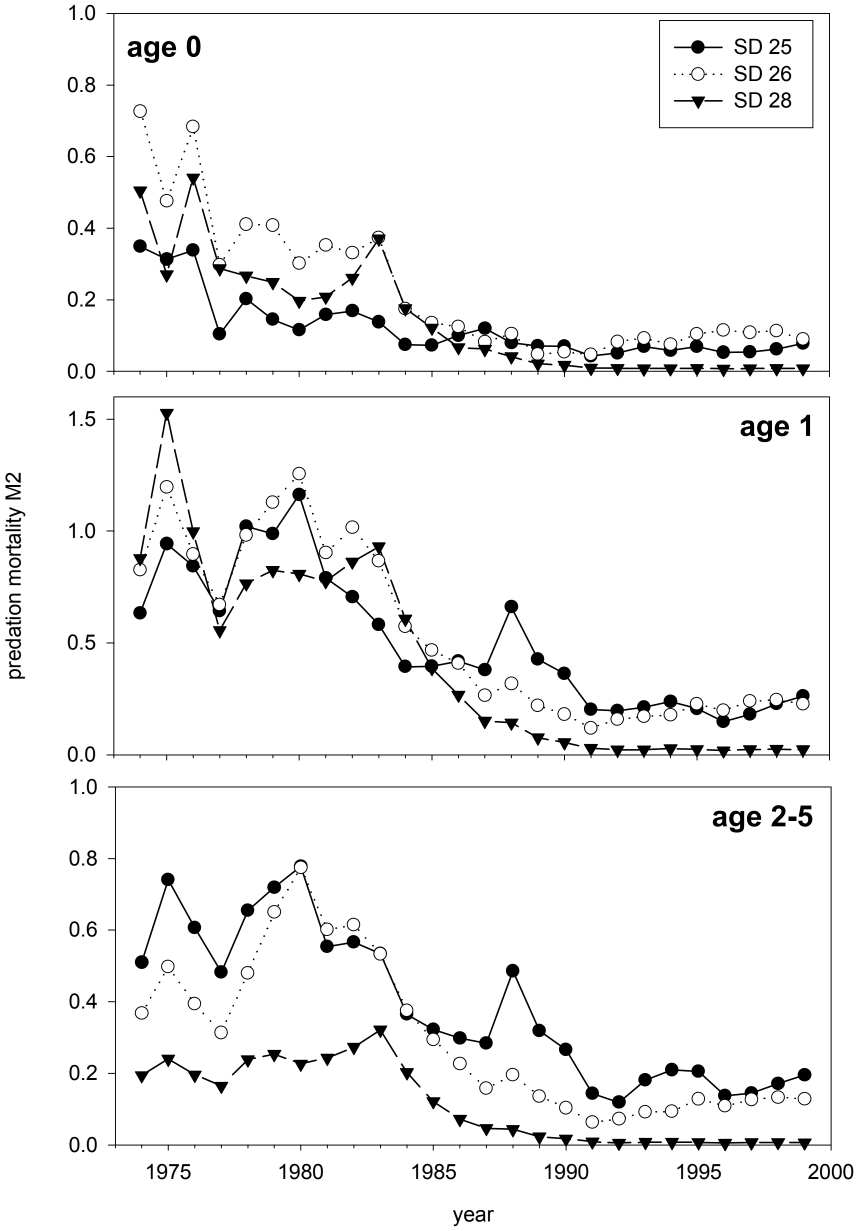


Fig. 5.3.13. Time-series of annual predation mortalities of sprat in the different Sub-divisions (SD) derived from area-disaggregated MSVPA.

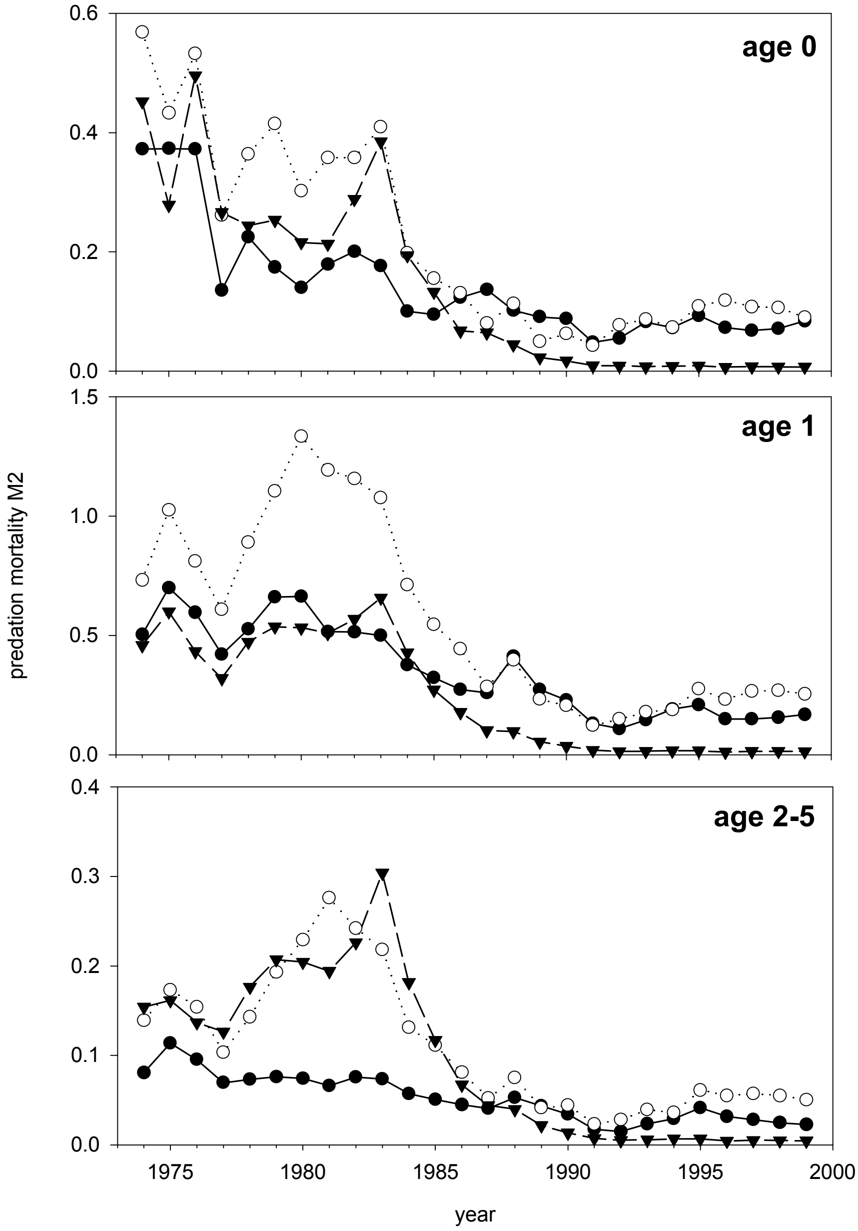


Fig. 5.3.14. Time-series of annual predation mortalities of herring in the different Sub-divisions (SD) derived from area-disaggregated MSVPA

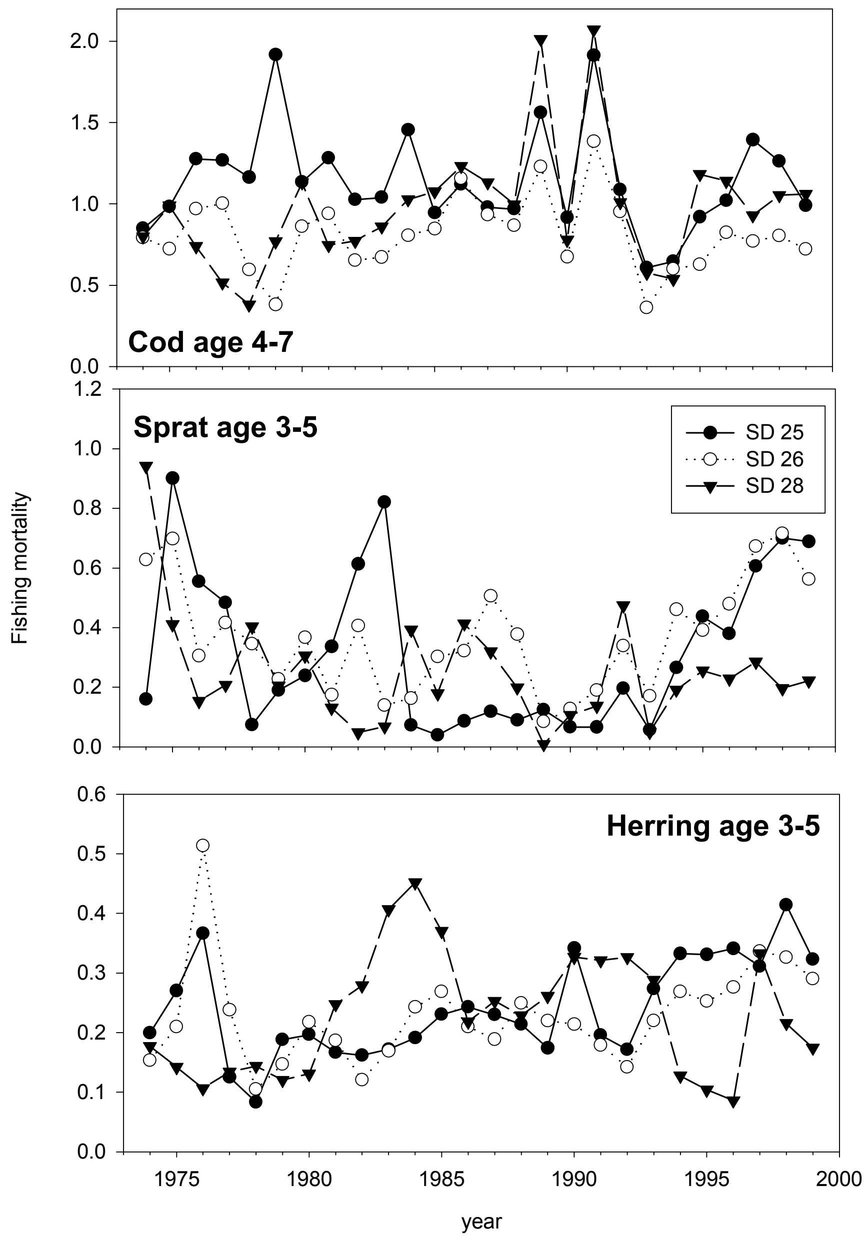


Fig. 5.3.15. Time-series of annual fishing mortalities of cod, sprat and herring in the different Sub-divisions (SD) derived from area-disaggregated MSVPA.

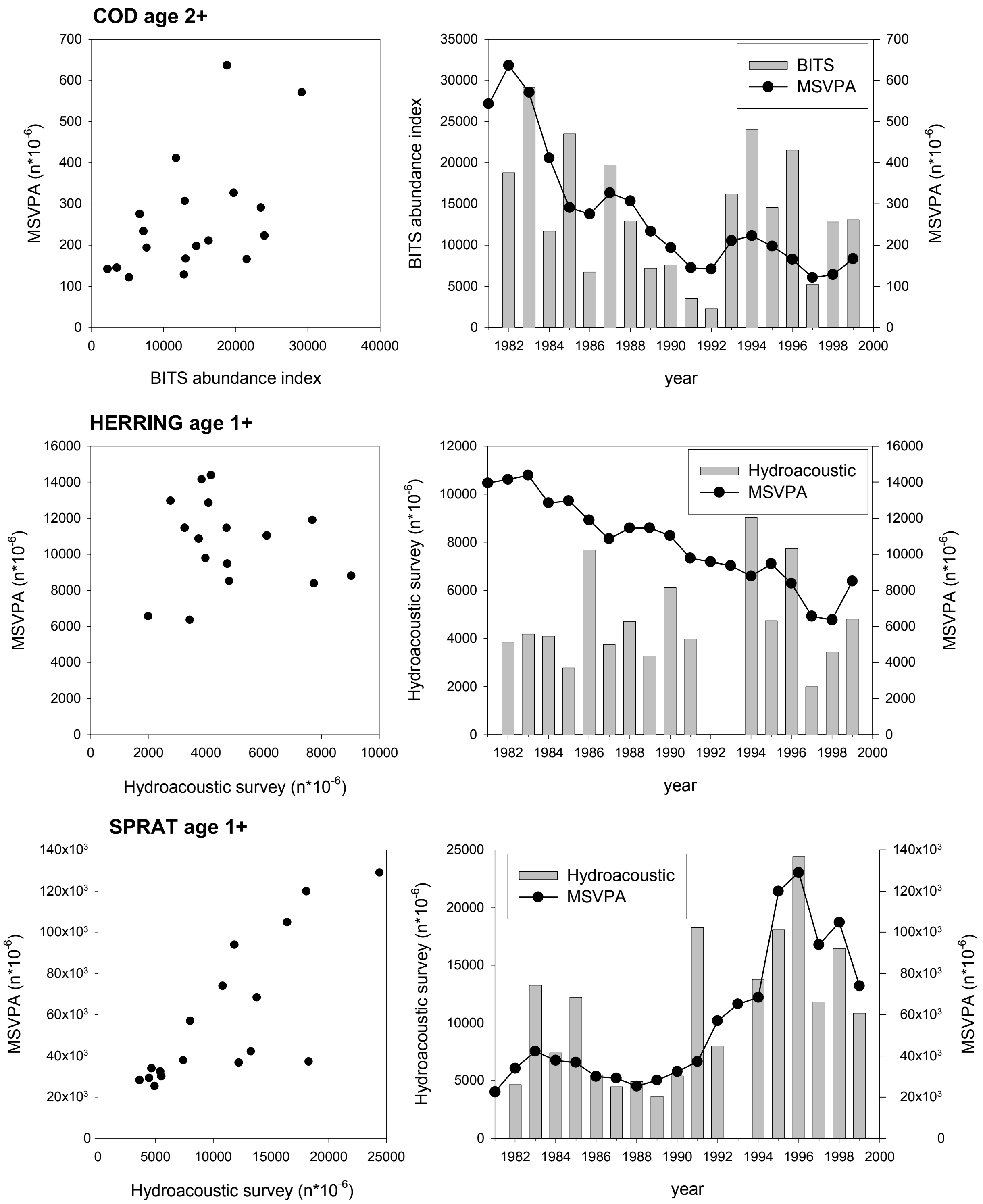


Fig. 5.3.16. Comparisons of stock sizes (1st quarter) in Sub-division 25 from area-disaggregated MSVPA for cod, herring and sprat with survey data used for tuning (cod: Baltic International Trawl Survey, BITS; herring and sprat: International Hydroacoustic Survey). Left panels: Correlations; right panels: time-series .

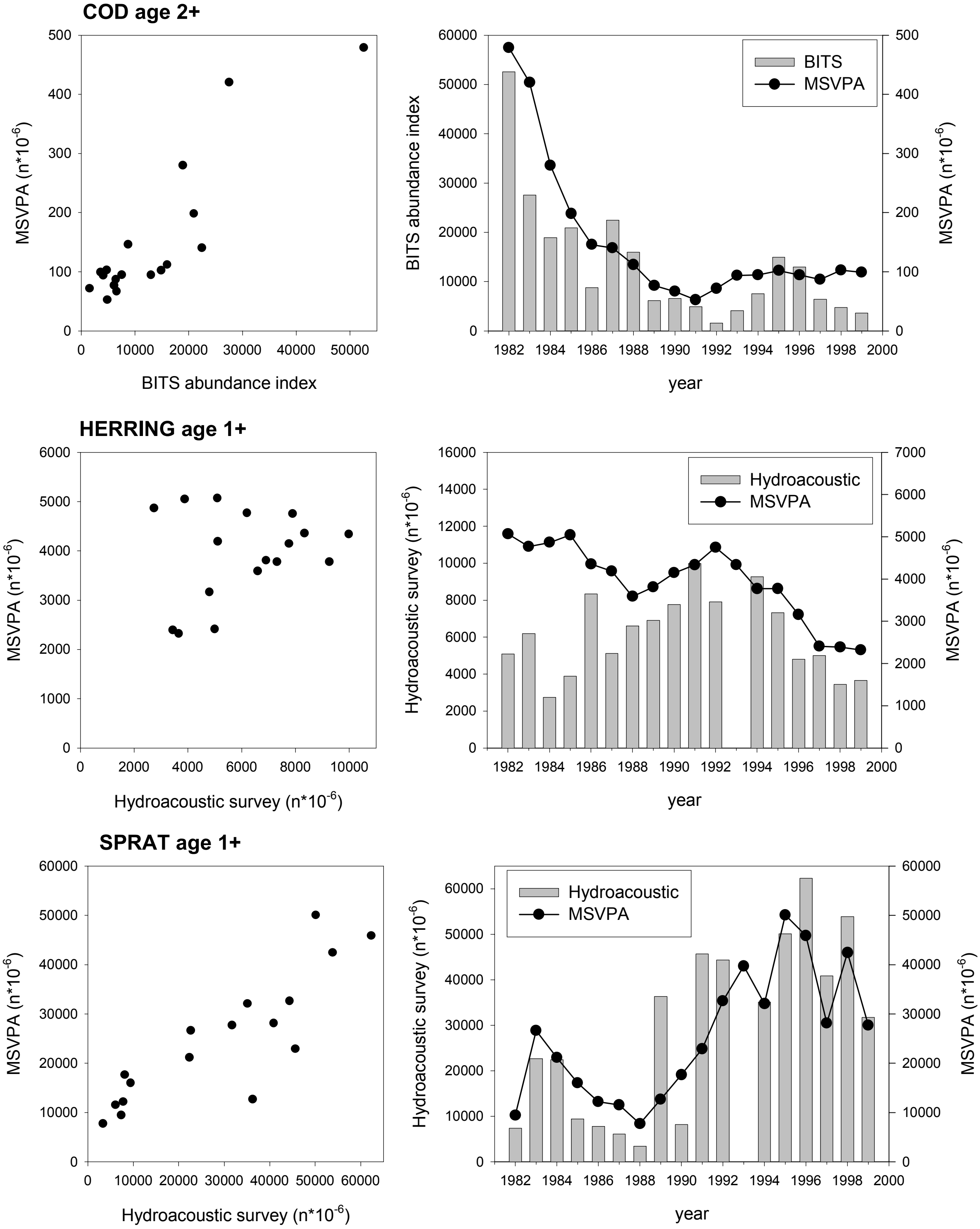


Fig. 5.3.17. Comparisons of stock sizes (1st quarter) in Sub-division 26 from area-disaggregated MSVPA for cod, herring and sprat with survey data used for tuning (cod: Baltic International Trawl Survey, BITS; herring and sprat: International Hydroacoustic Survey). Left panels: Correlations; right panels: time-series.

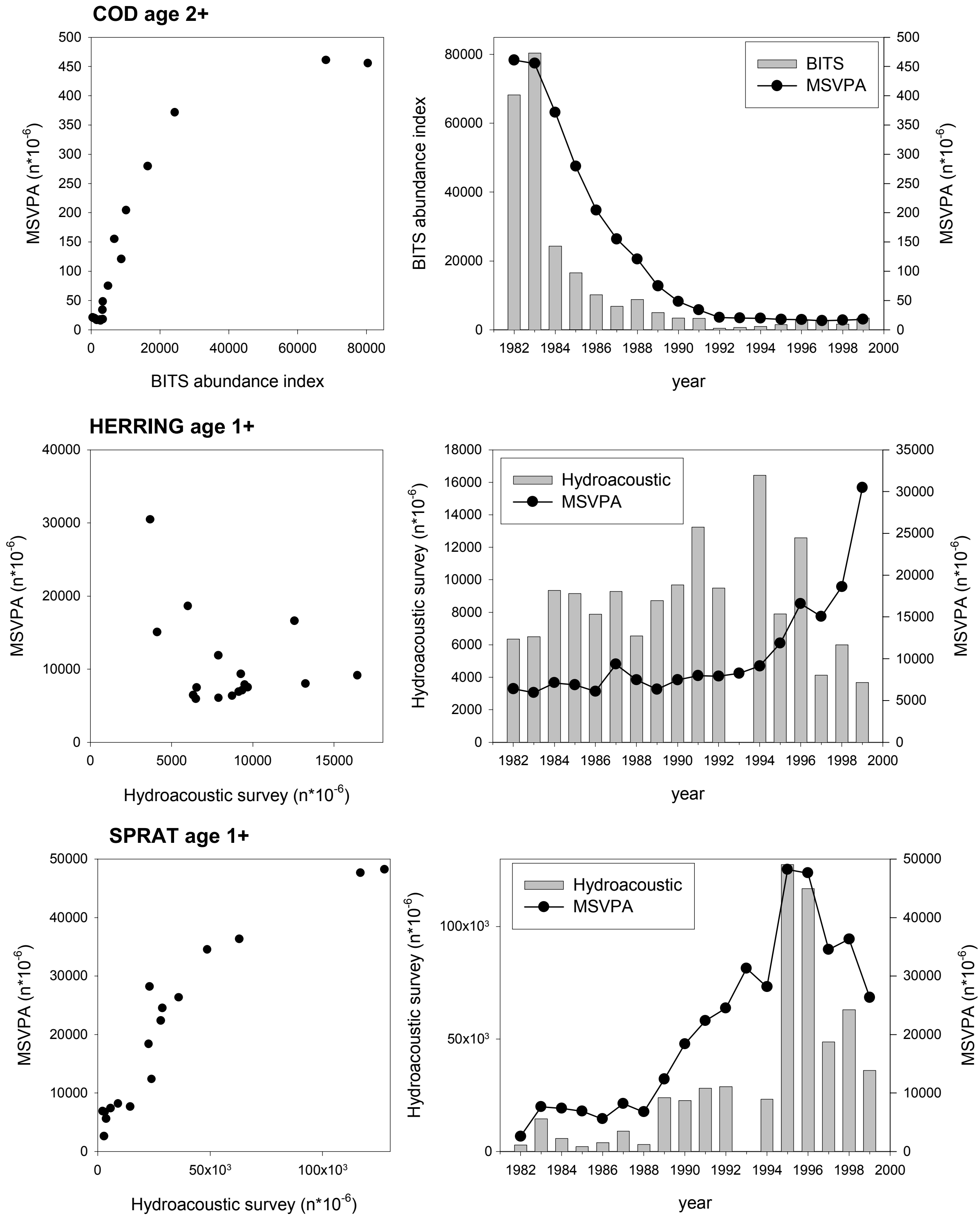


Fig. 5.3.18. Comparisons of stock sizes (1st quarter) in Sub-division 28 from area-disaggregated MSVPA for cod, herring and sprat with survey data used for tuning (cod: Baltic International Trawl Survey, BITS; herring and sprat: International Hydroacoustic Survey). Left panels: Correlations; right panels: time-series.

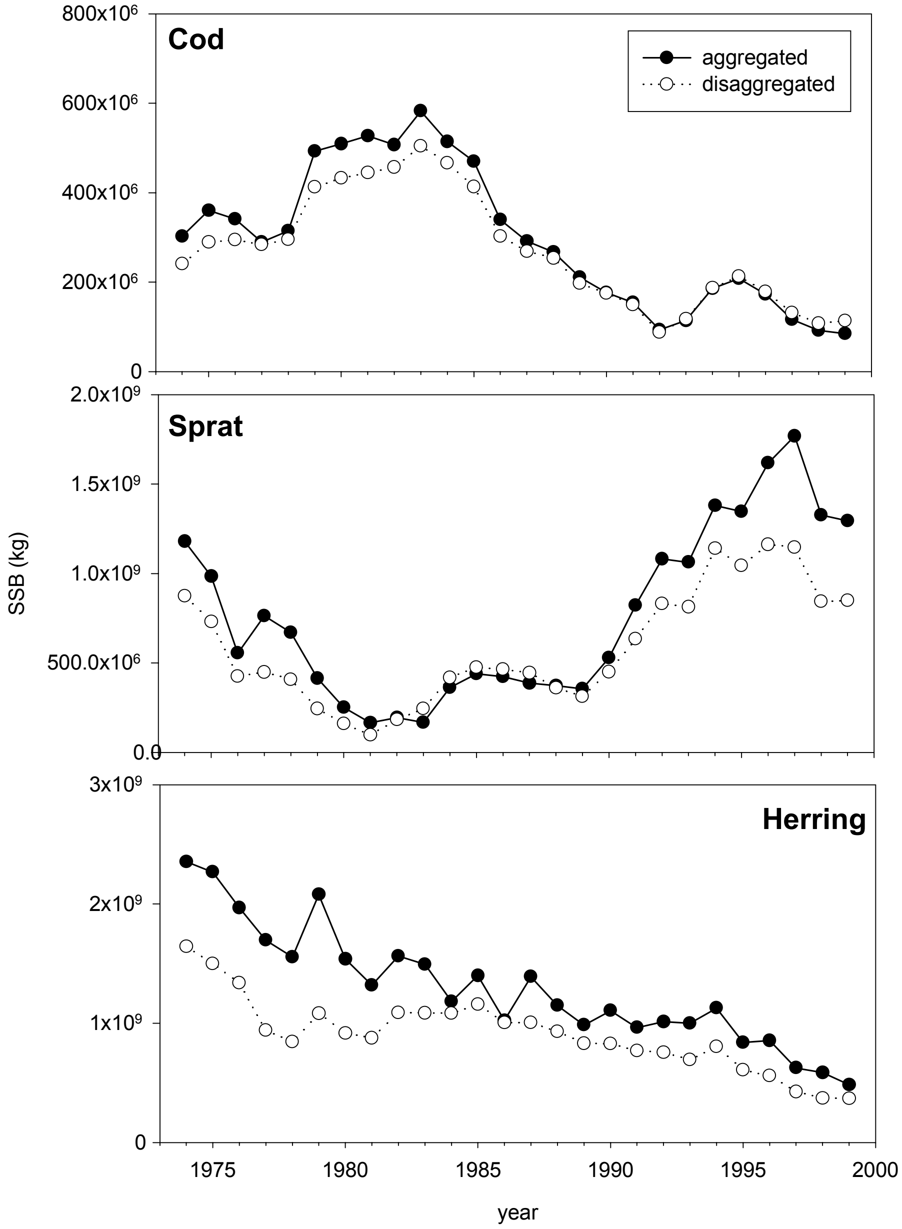


Fig. 5.3.19. Time-series of spawning stock biomass (SSB, 1st quarter) of cod, sprat and herring derived from area-aggregated and area-disaggregated MSVPA.

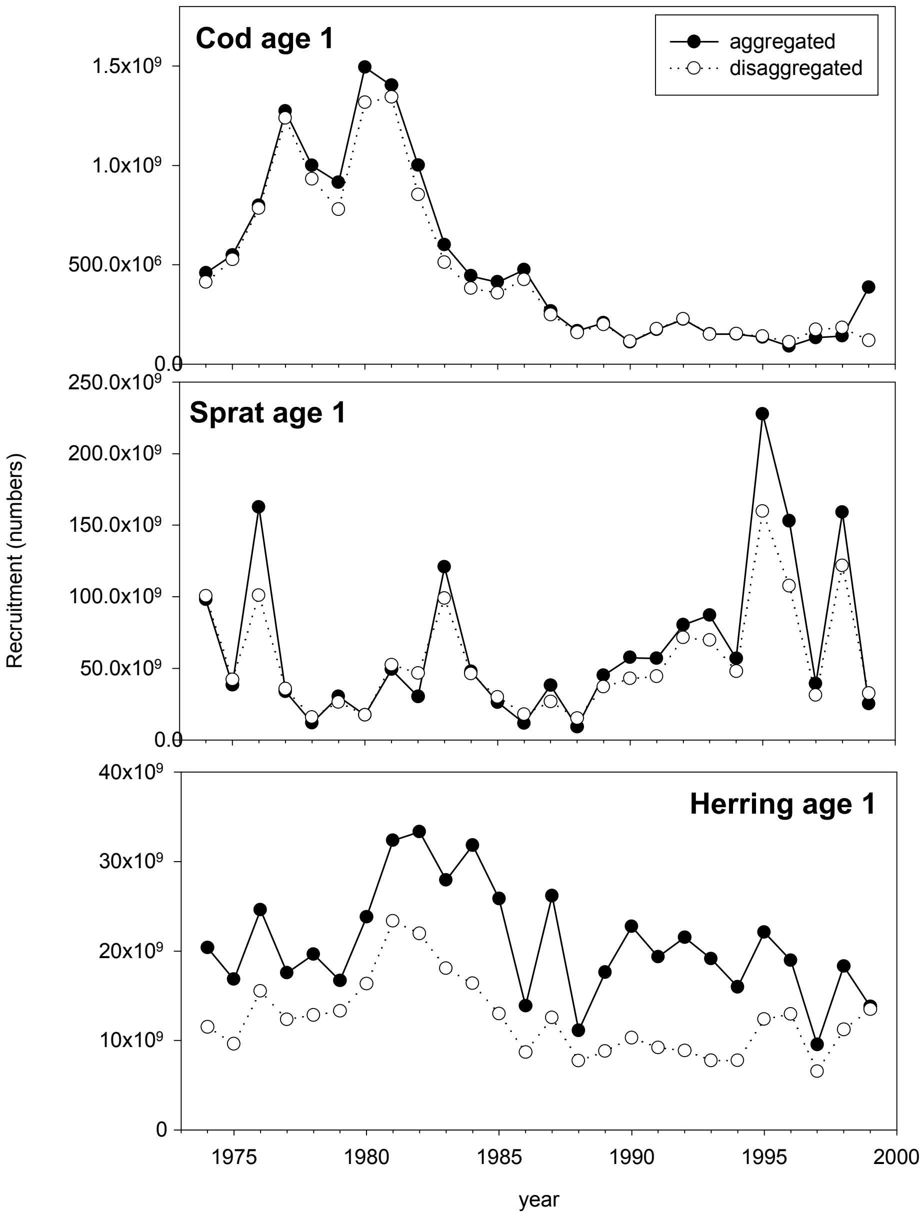


Fig. 5.3.20. Time-series of recruitment estimates (1st quarter) of cod, sprat and herring derived from area-aggregated and area-disaggregated MSVPA.

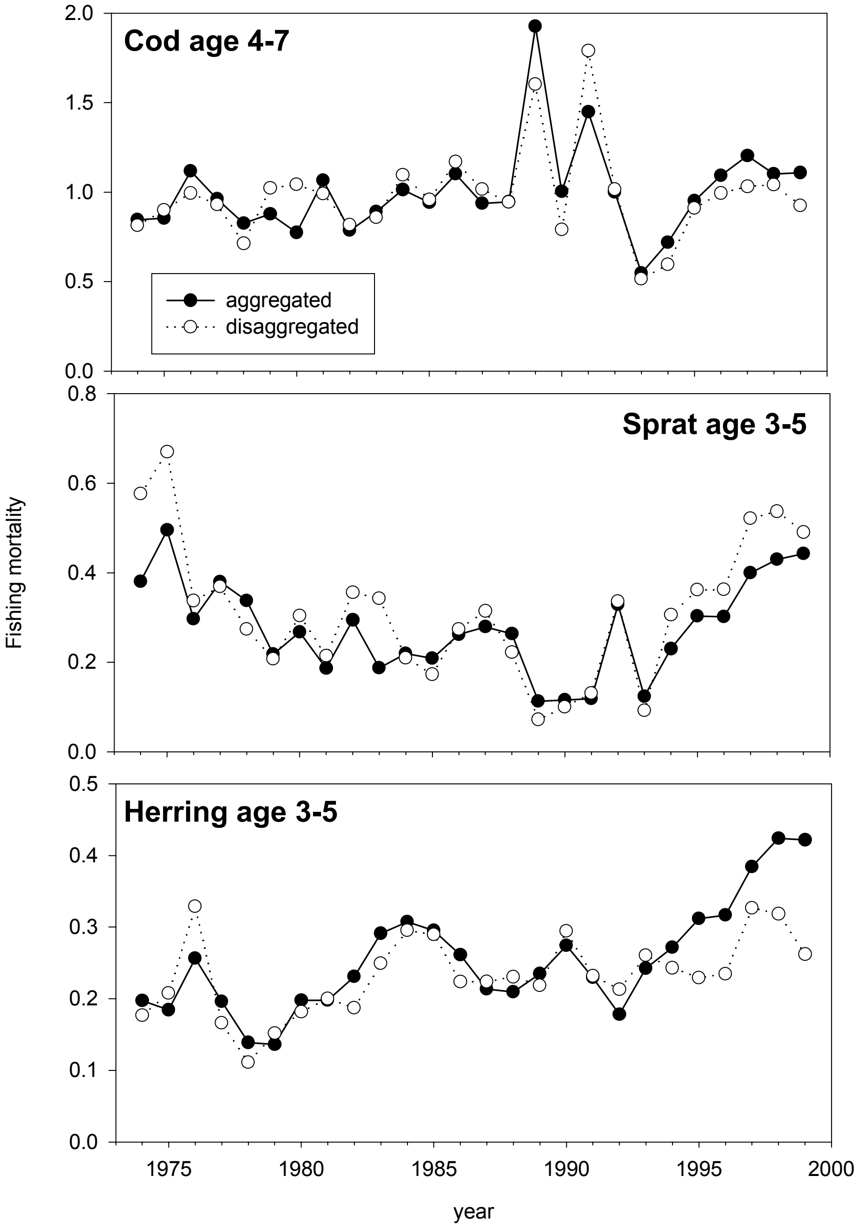


Fig. 5.3.21. Time-series of annual fishing mortalities of cod, sprat and herring derived from area-aggregated and area-disaggregated MSVPA

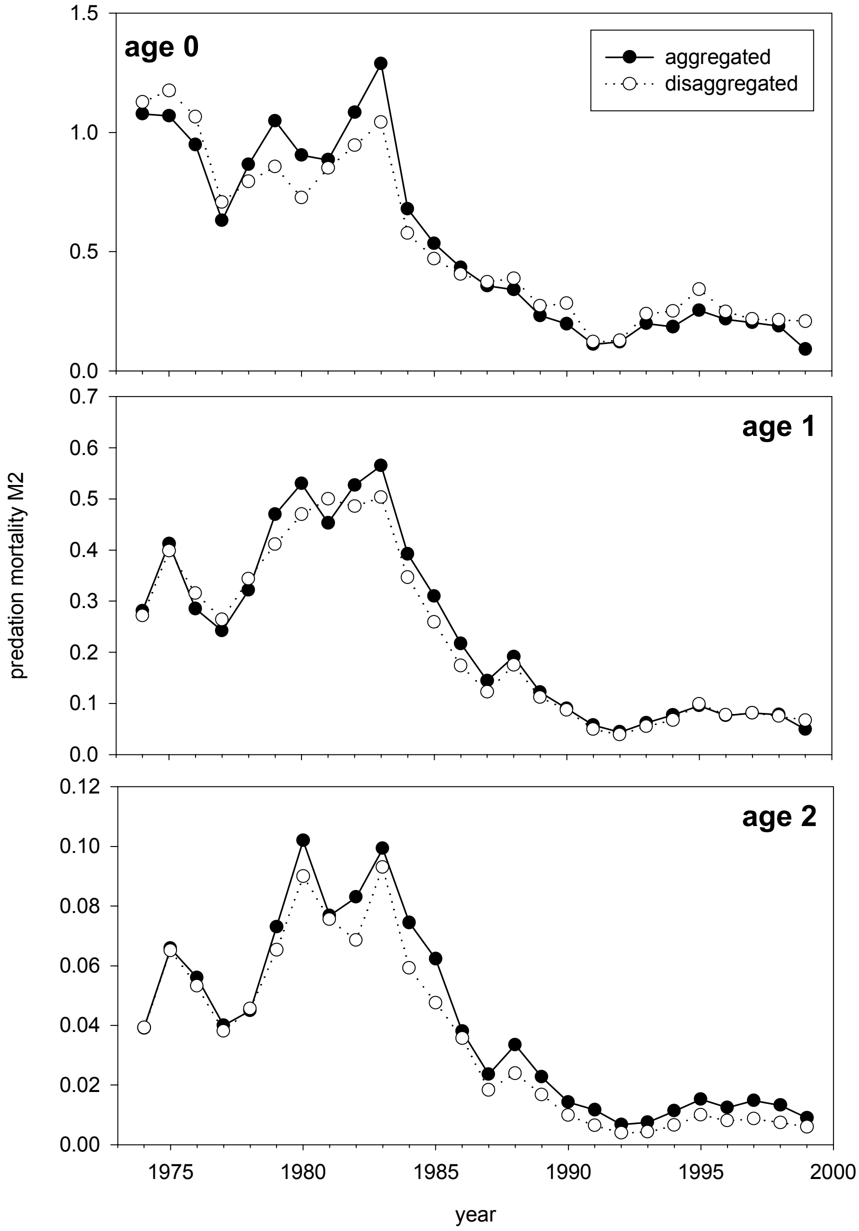


Fig. 5.3.22. Time-series of annual predation mortalities of cod derived from area-aggregated and area-disaggregated MSVPA.

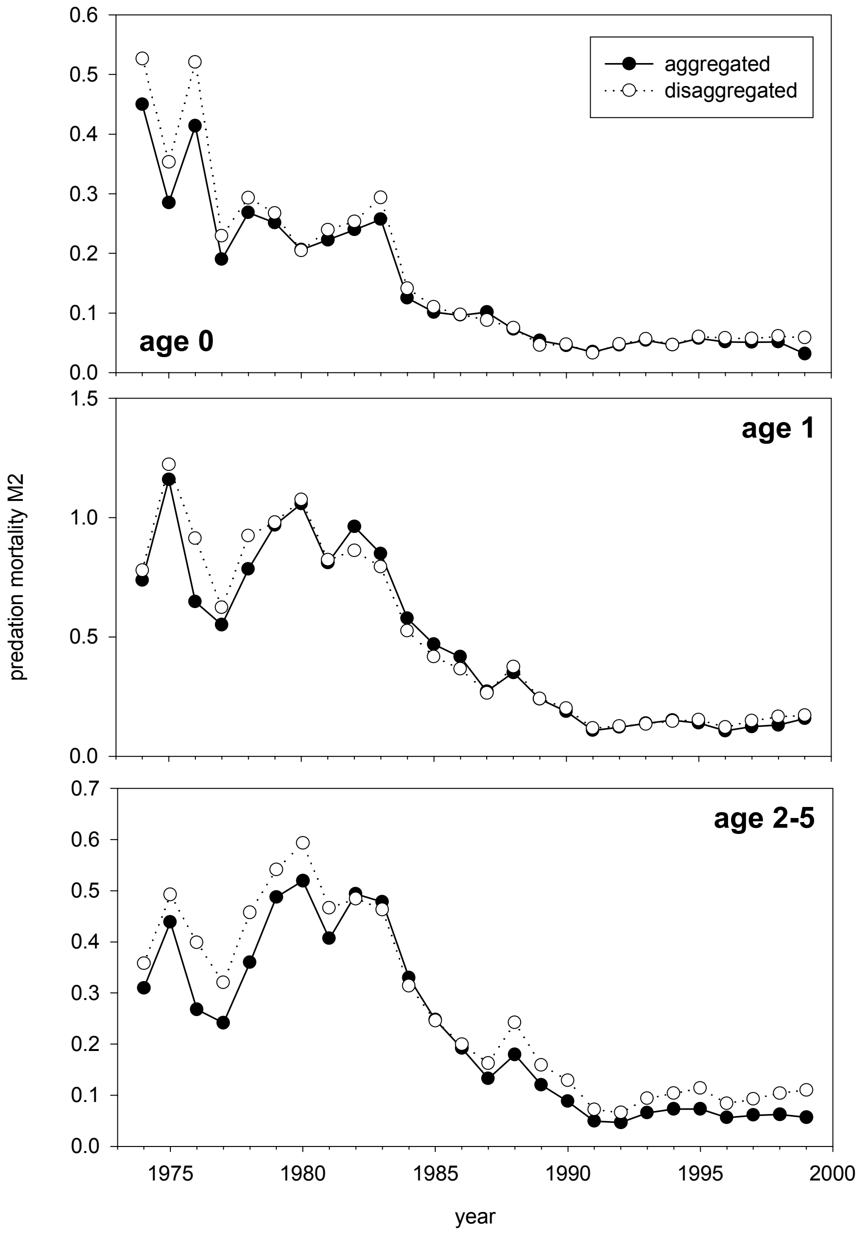


Fig. 5.3.23. Time-series of annual predation mortalities of sprat derived from area-aggregated and area-disaggregated MSVPA.

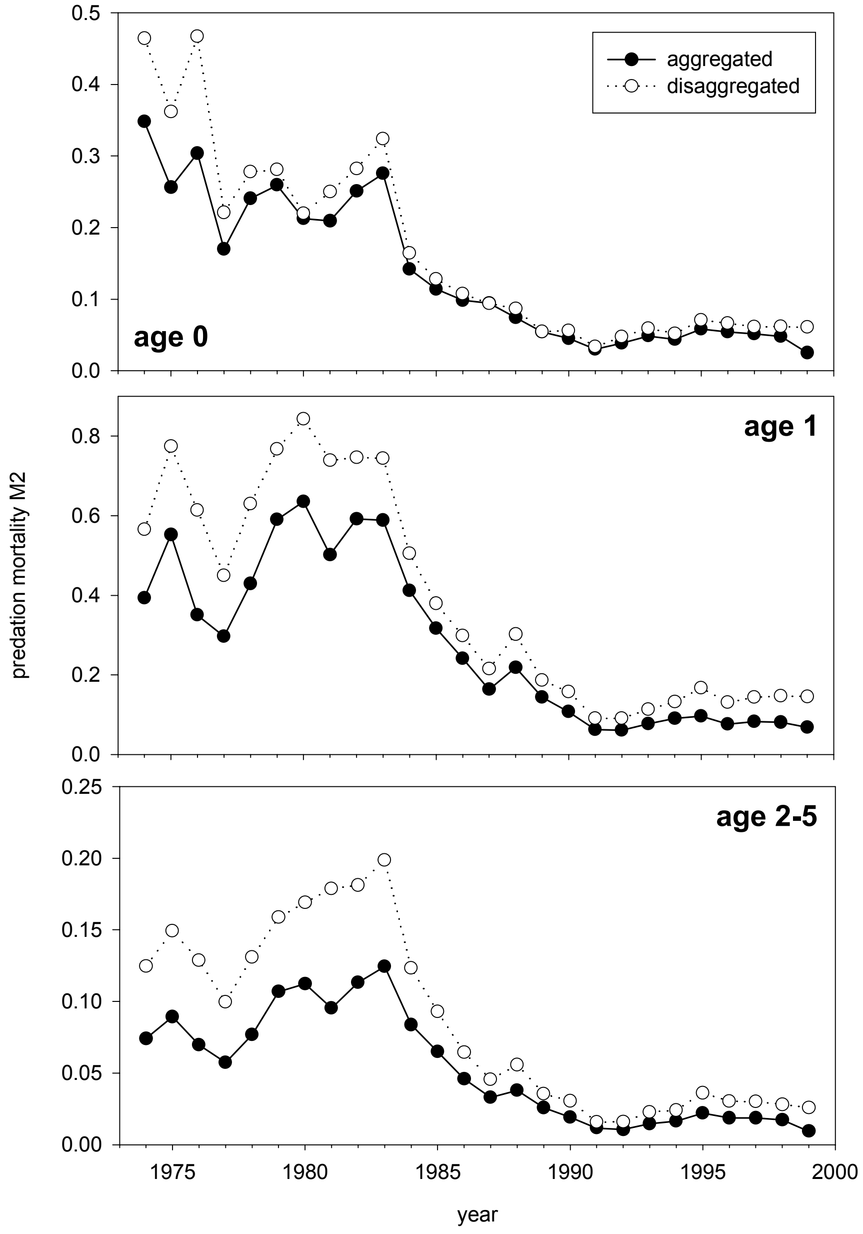


Fig. 5.3.24. Time-series of annual predation mortalities of herring derived from area-aggregated and area-disaggregated MSVPA.

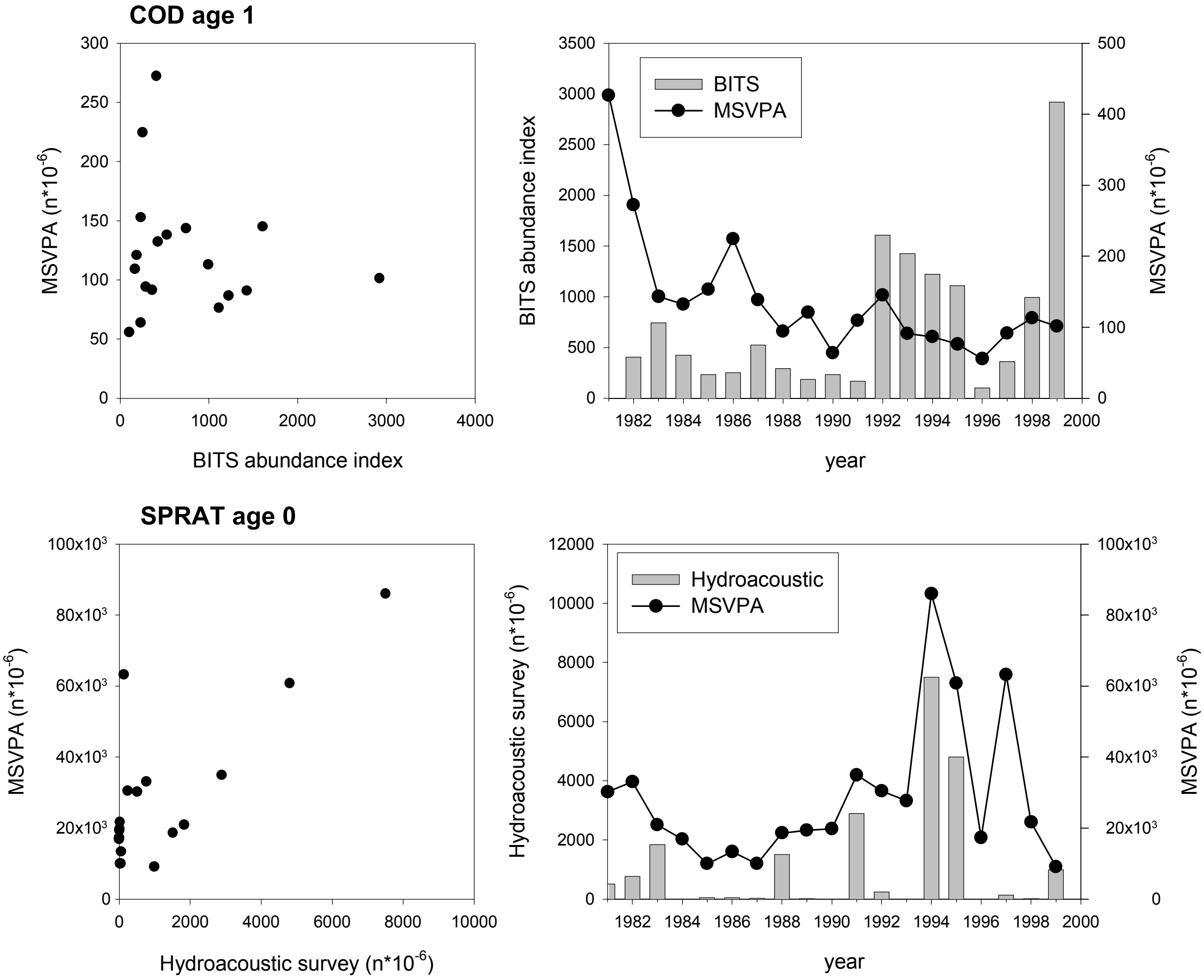


Fig. 5.3.25. Comparisons of recruitment estimates (1st quarter) in Sub-division 25 from area-disaggregated MSVPA for cod and sprat with survey data used for tuning (cod: Baltic International Trawl Survey, BITS; sprat: International Hydroacoustic Survey). Left panels: Correlations; right panels: time-series.

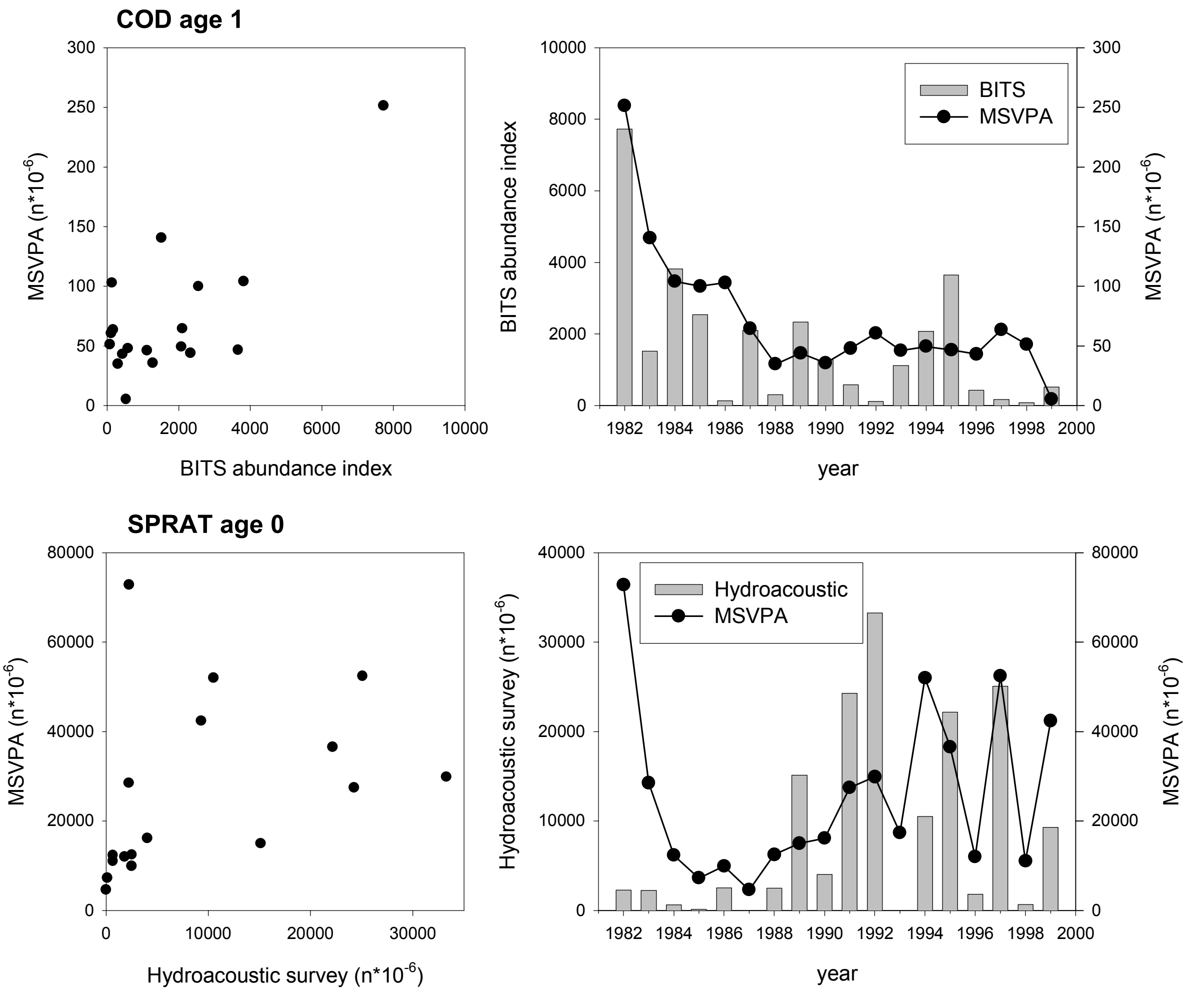


Fig. 5.3.26. Comparisons of recruitment estimates (1st quarter) in Sub-division 26 from area-disaggregated MSVPA for cod and sprat with survey data used for tuning (cod: Baltic International Trawl Survey, BITS; sprat: International Hydroacoustic Survey). Left panels: Correlations; right panels: time-series.

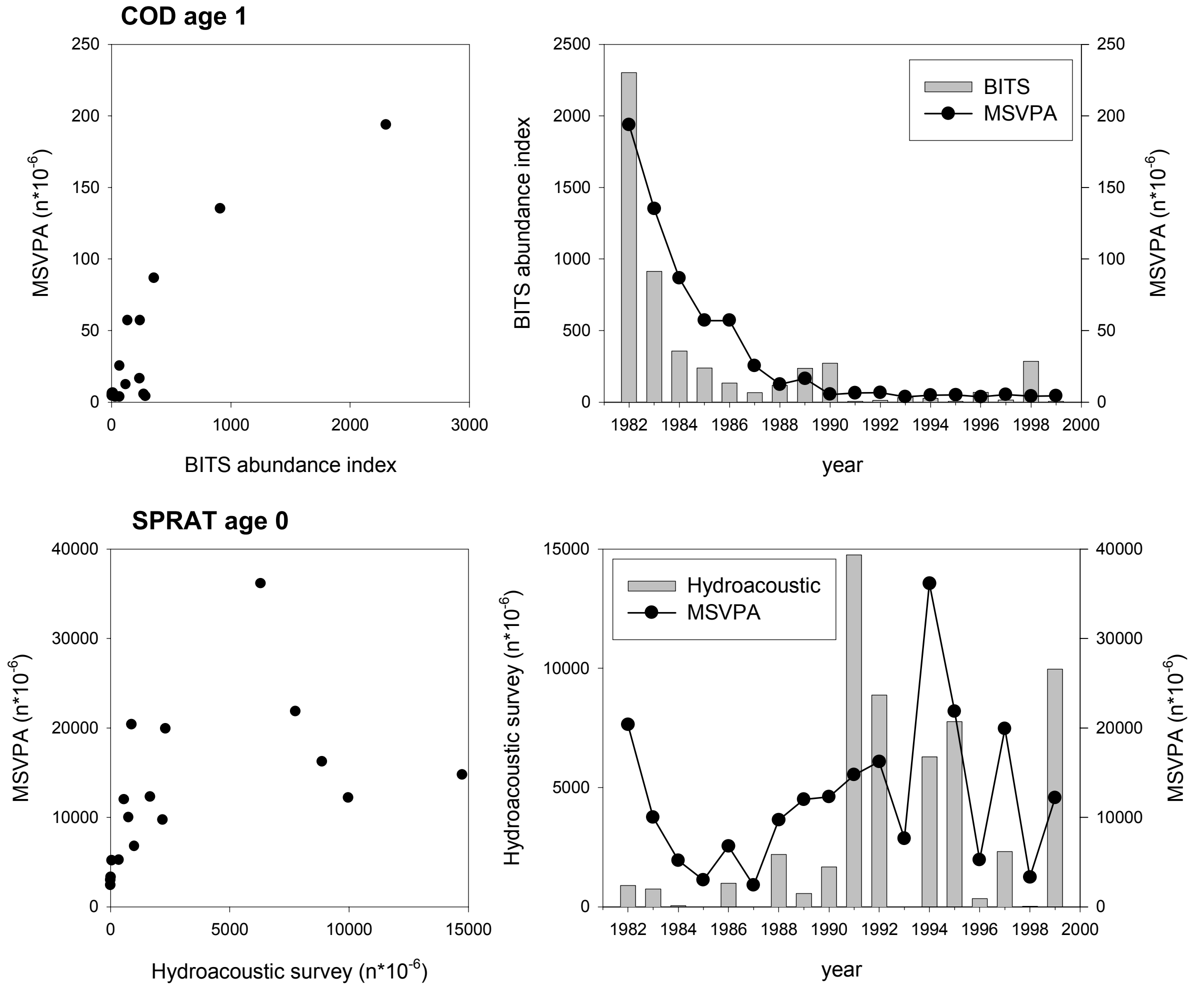


Fig. 5.3.27. Comparisons of recruitment estimates (1st quarter) in Sub-division 28 from area-disaggregated MSVPA for cod and sprat with survey data used for tuning (cod: Baltic International Trawl Survey, BITS; sprat: International Hydroacoustic Survey). Left panels: Correlations; right panels: time-series.

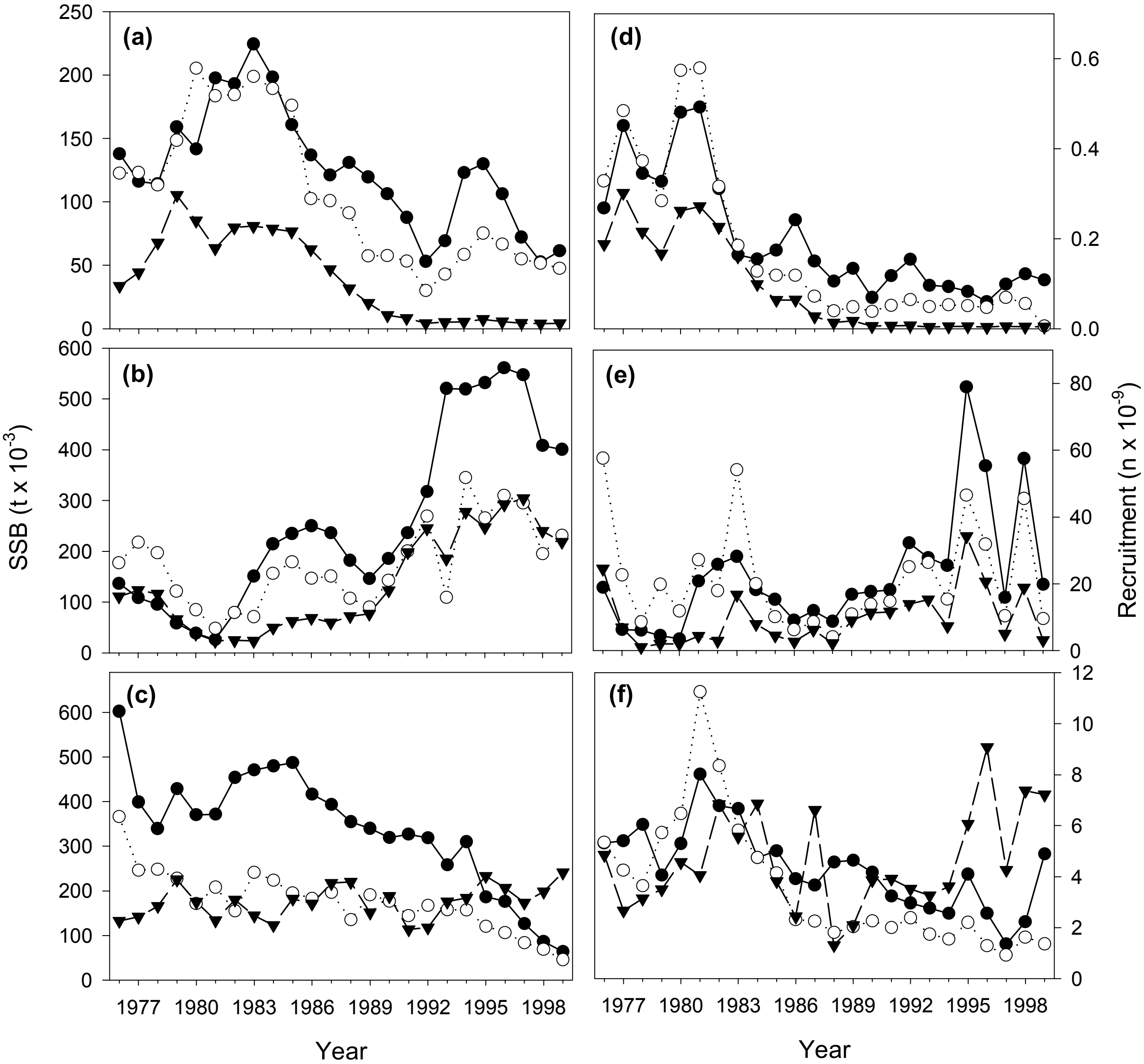


Fig. 6.1.1. Spawning stock biomass (2nd quarter) of cod (a), sprat (b) and herring (c) and recruitment at age 1 (beginning of the year) of cod (d), sprat (e) and herring (f) from area dis-aggregated MSVPA in different Sub-divisions (black dots – Sub-division 25, white dots – Sub-division 26, triangles – Sub-division 28).

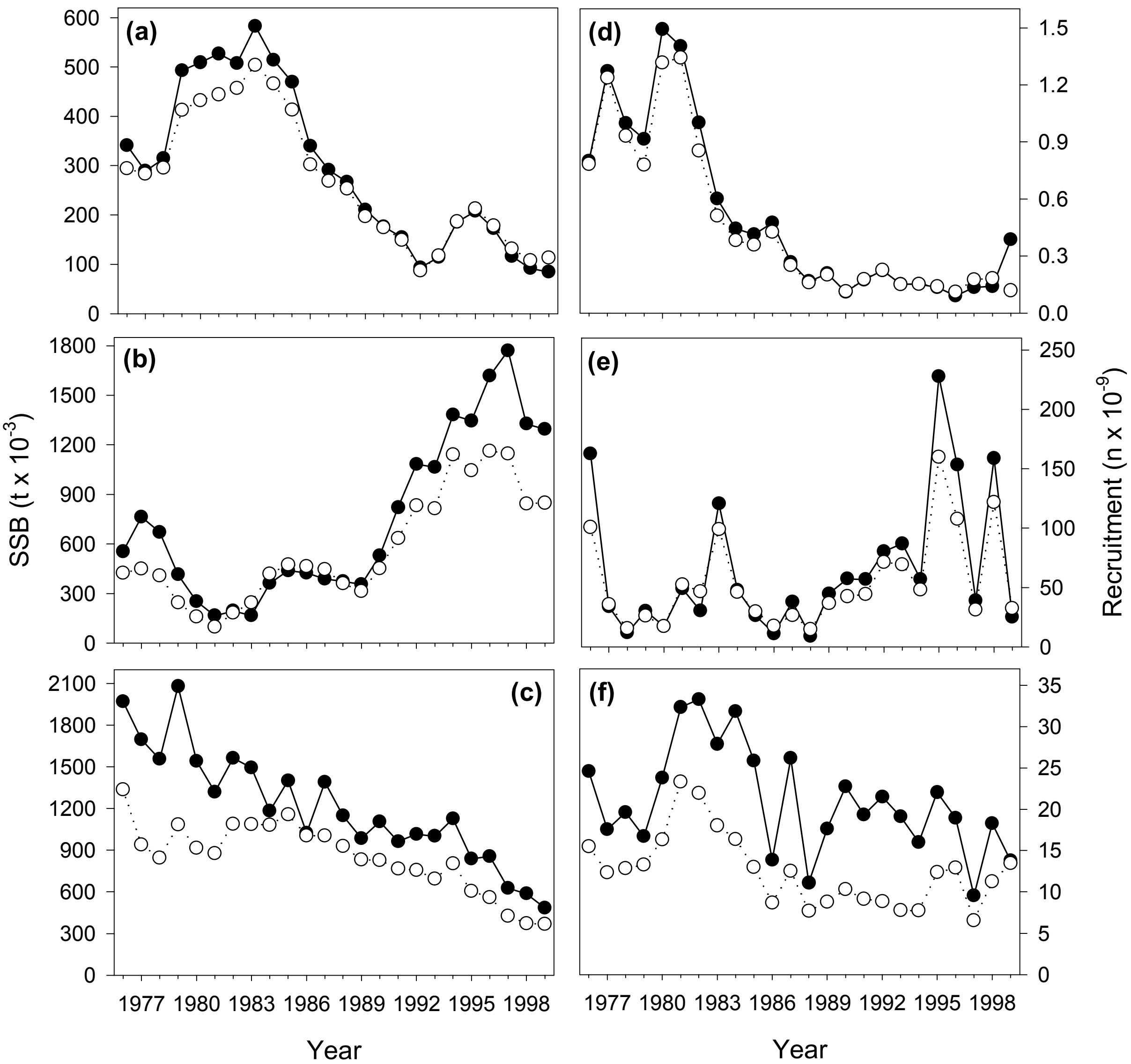


Fig. 6.1.2. Spawning stock biomass derived by area dis-aggregated MSVPA and standard stock assessments (XSA) (both at the beginning of the year) of (a) cod, (b) herring and (c) sprat and recruitment of (d) cod (age-group 2), (e) sprat (age-group 1) and (f) herring (age-group 1) (solid circles: MSVPA, open circles: XSA).

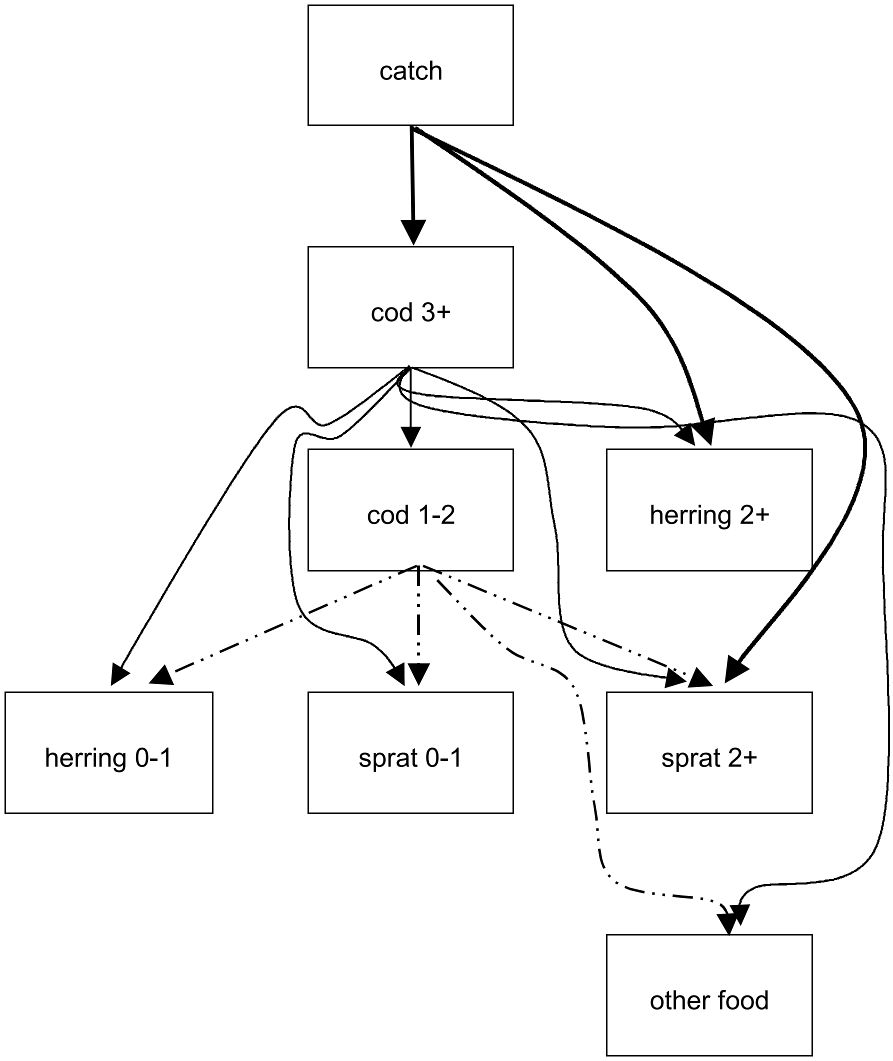
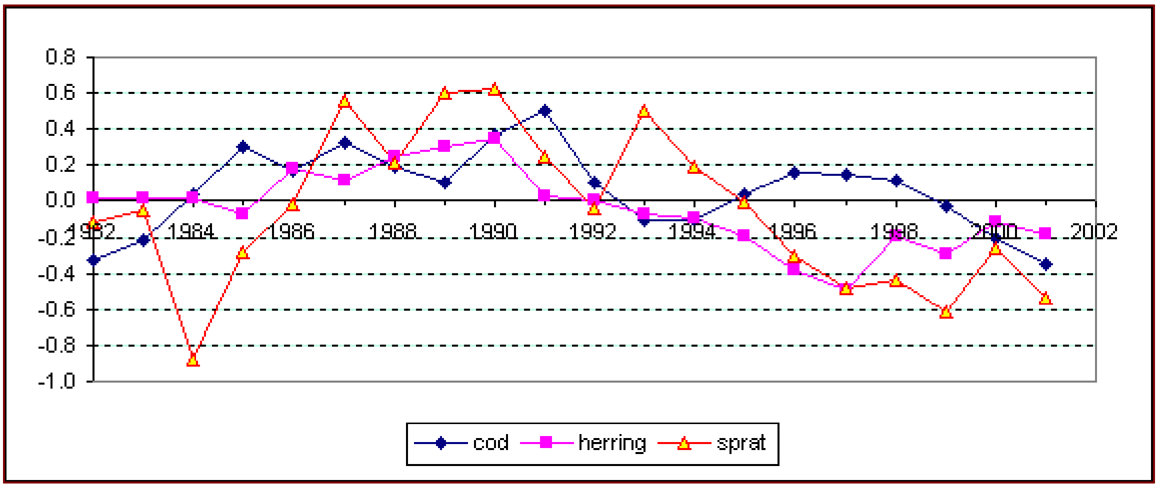


Fig. 6.1.3. The trophic interactions in the Baltic simulated in the multispecies production model.

catch residuals



residuals of food composition

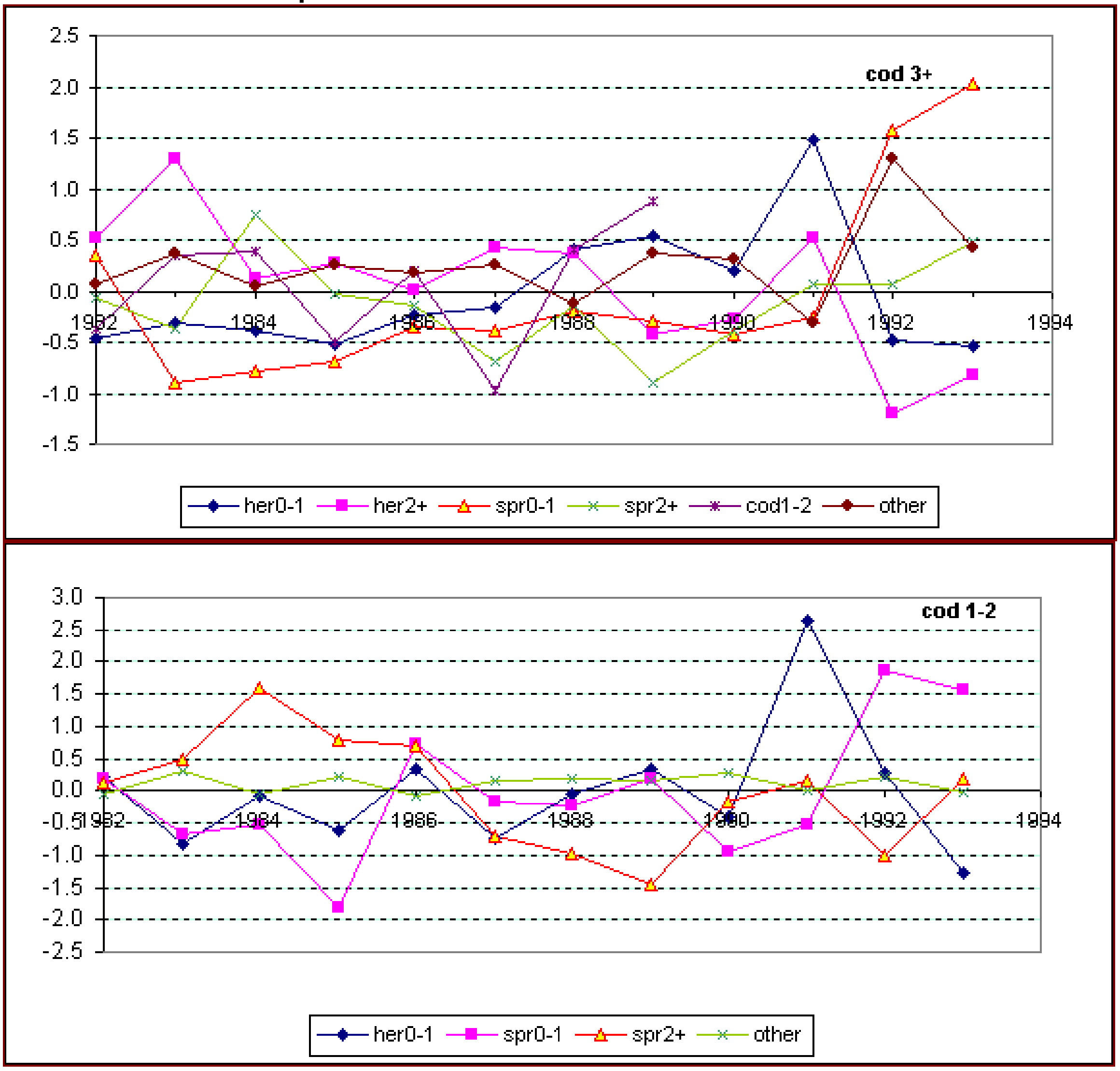
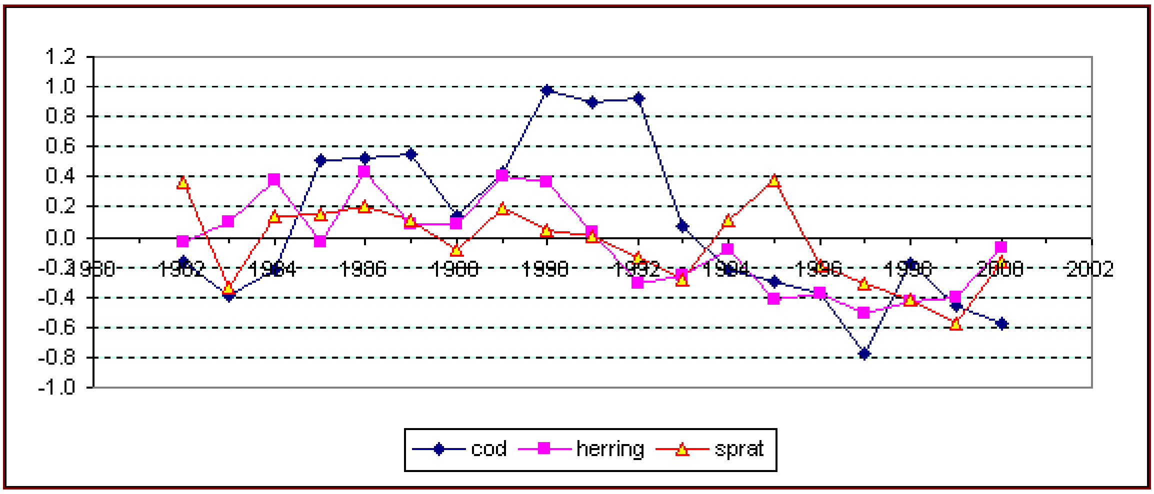
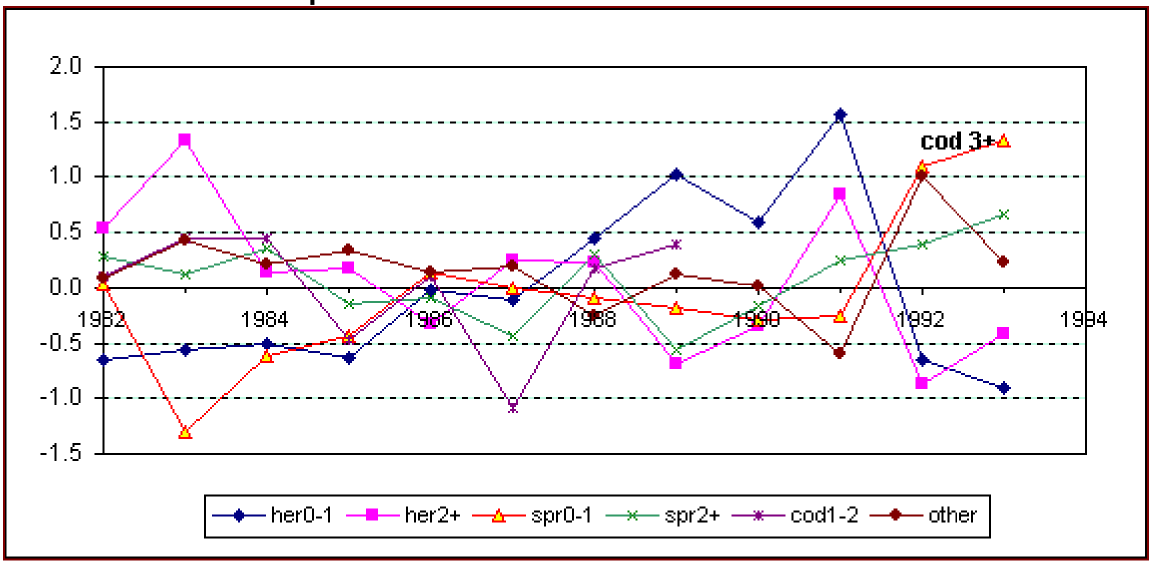


Fig. 6.1.4. Log catch and food composition residuals in the multispecies production model fit (XSA-based model; her – herring, spr - sprat).

catch residuals



residuals of food composition



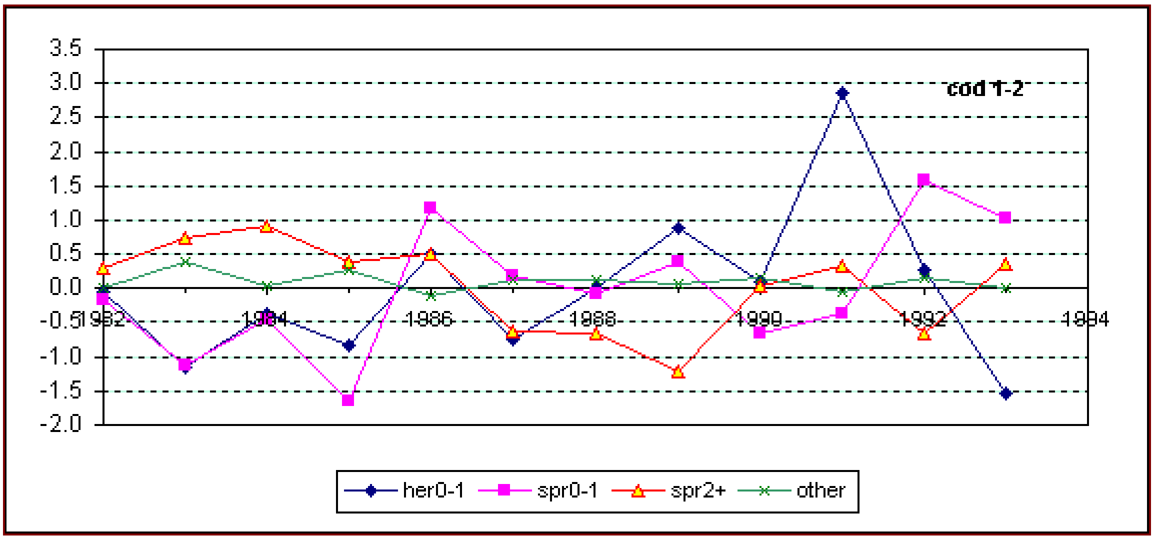


Fig. 6.1.5. Log catch and food composition residuals in the multispecies production model fit (survey-based model; her – herring, spr - sprat).

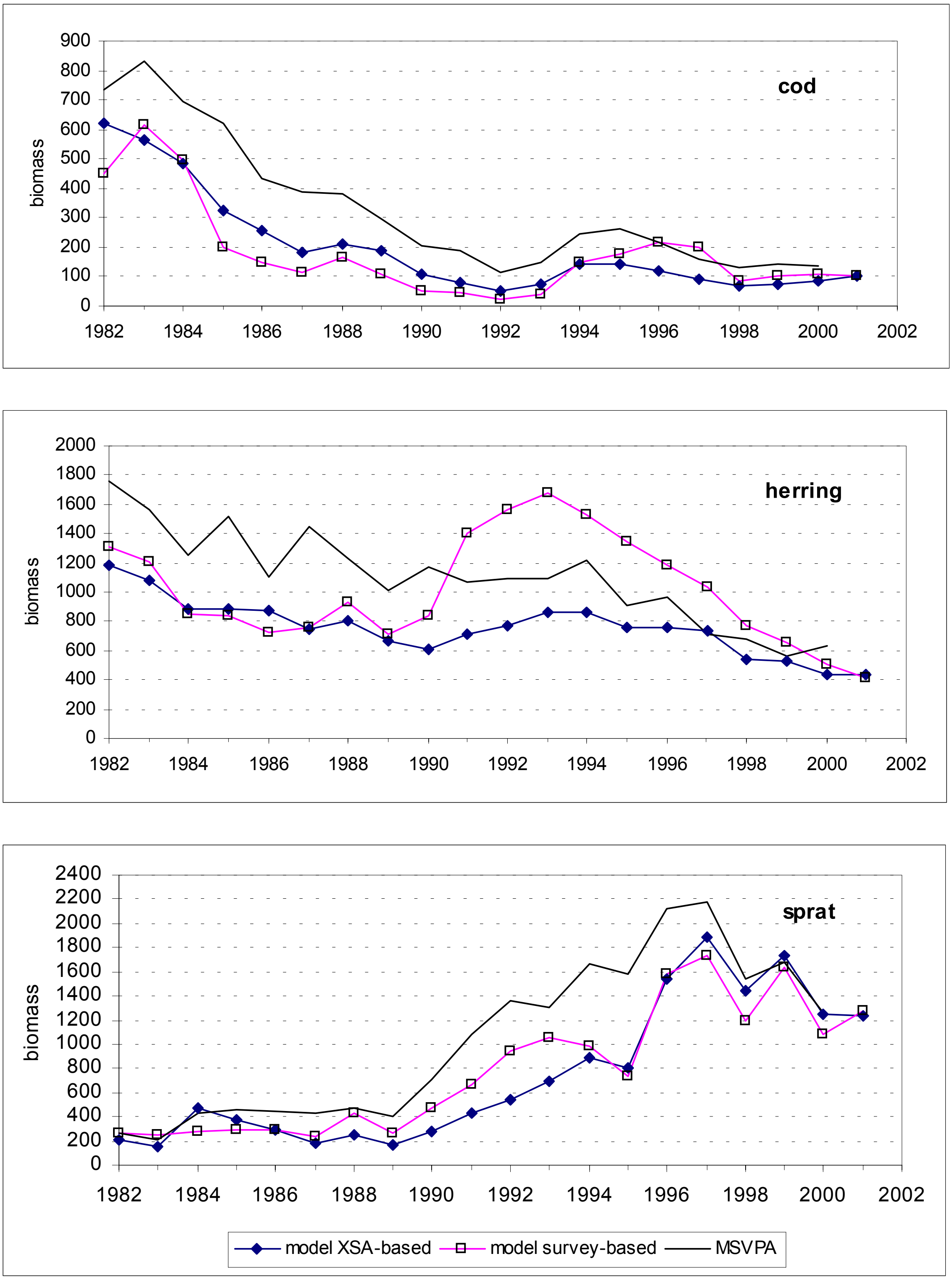


Fig. 6.1.6 A comparison of the biomass (000' t) of adult component of cod, herring and sprat estimated from the multispecies production model, with corresponding estimates obtained from MSVPA for 1982-2001.

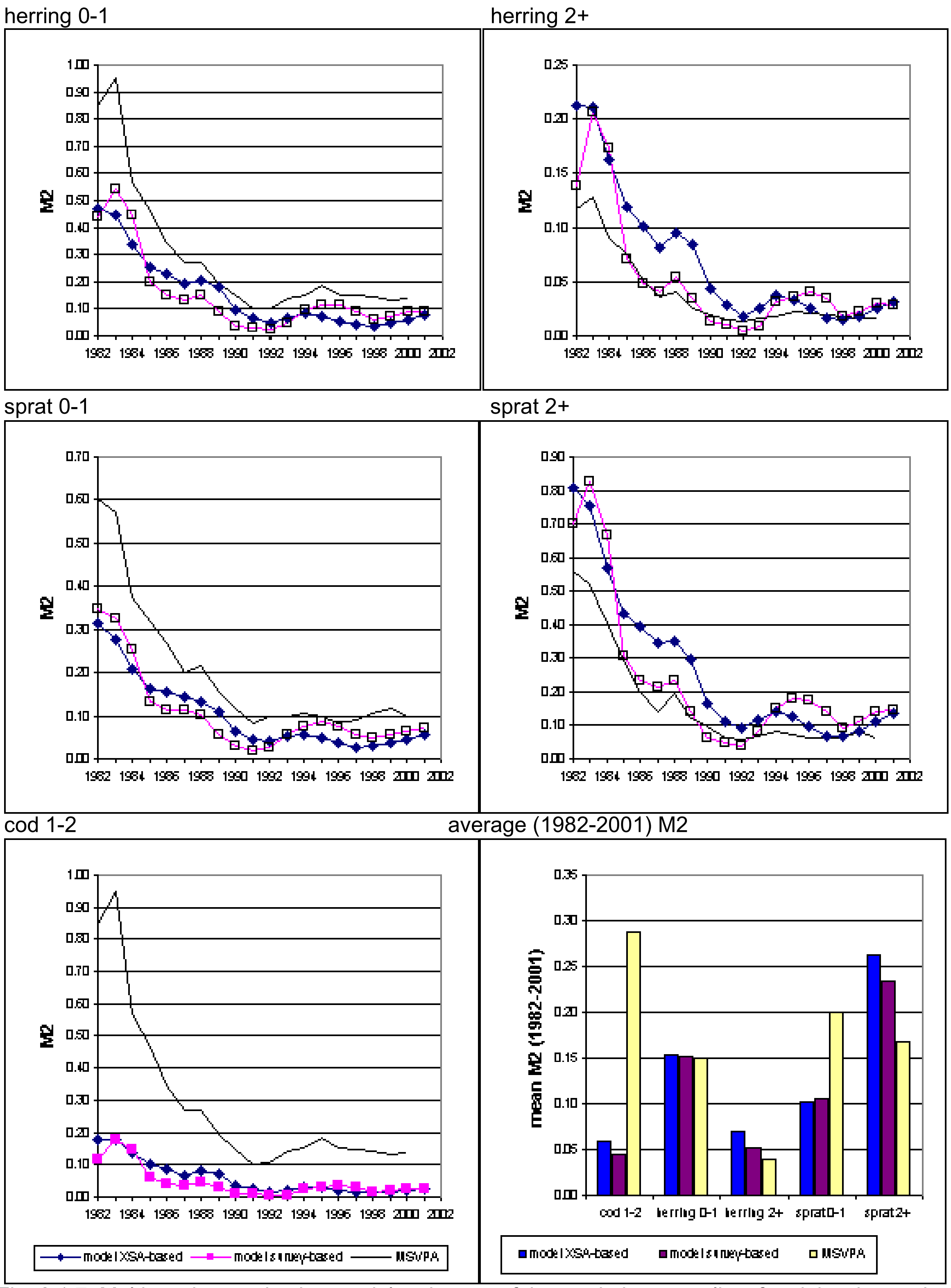


Fig. 6.1.7. Multispecies production model estimates of the predation mortality of cod, herring and sprat and the corresponding estimates from MSVPA.

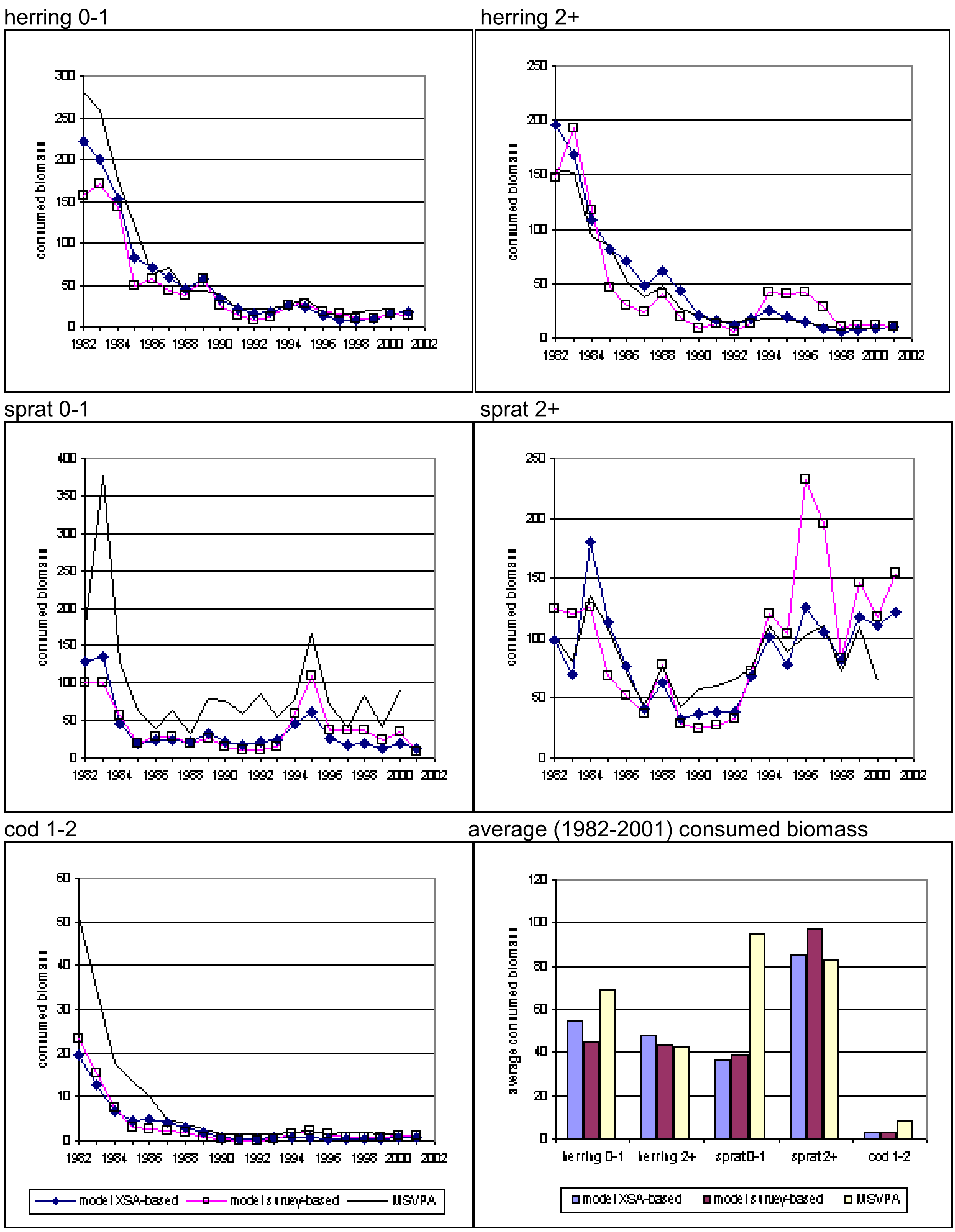


Fig. 6.1.8. Estimates of consumed biomass of cod, herring and sprat obtained with the multispecies production model compared with consumed biomass determined by MSVPA.

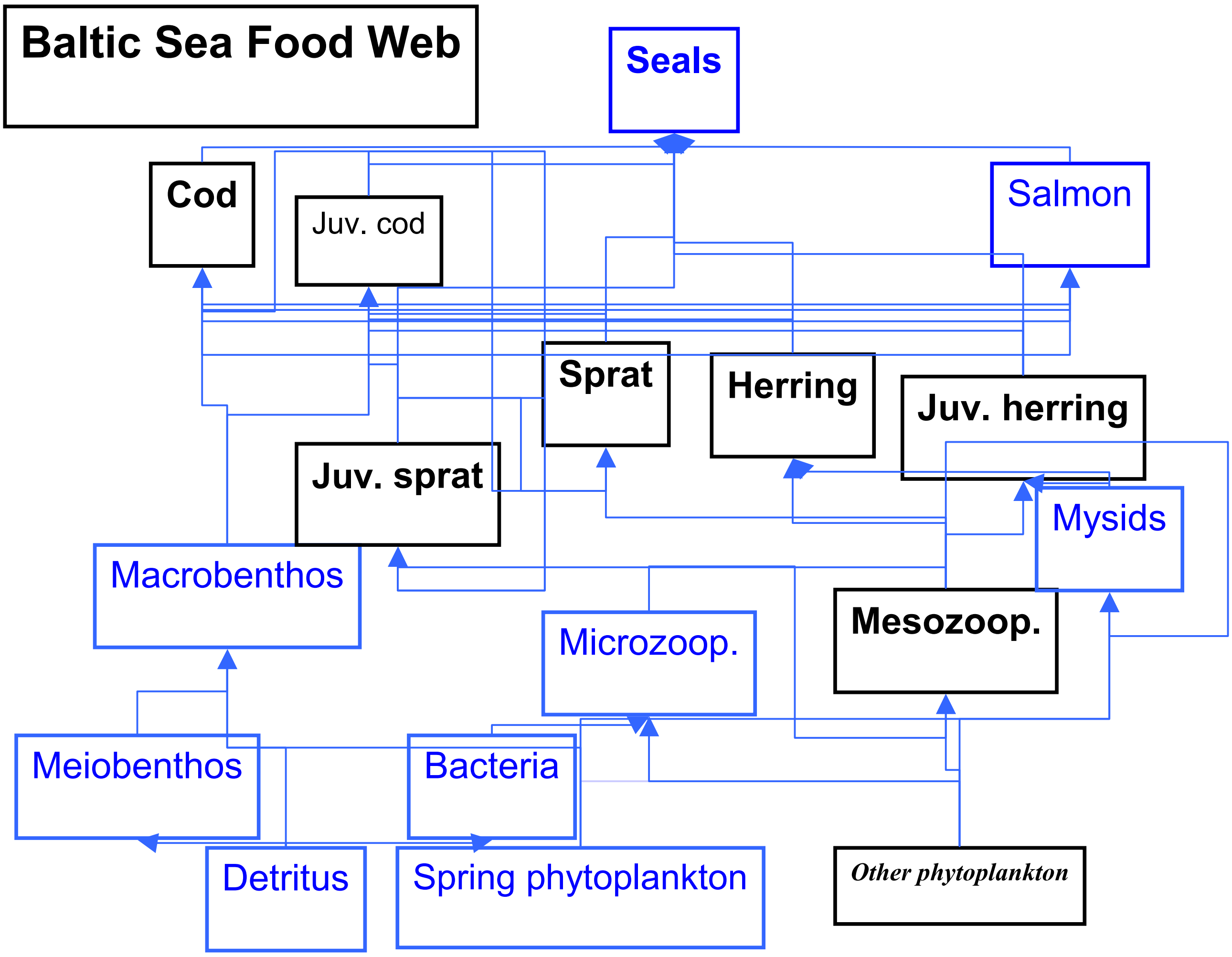


Fig. 6.1.9. Baltic Sea food web used in the analysis (boxes in bold included into the analysis and results).

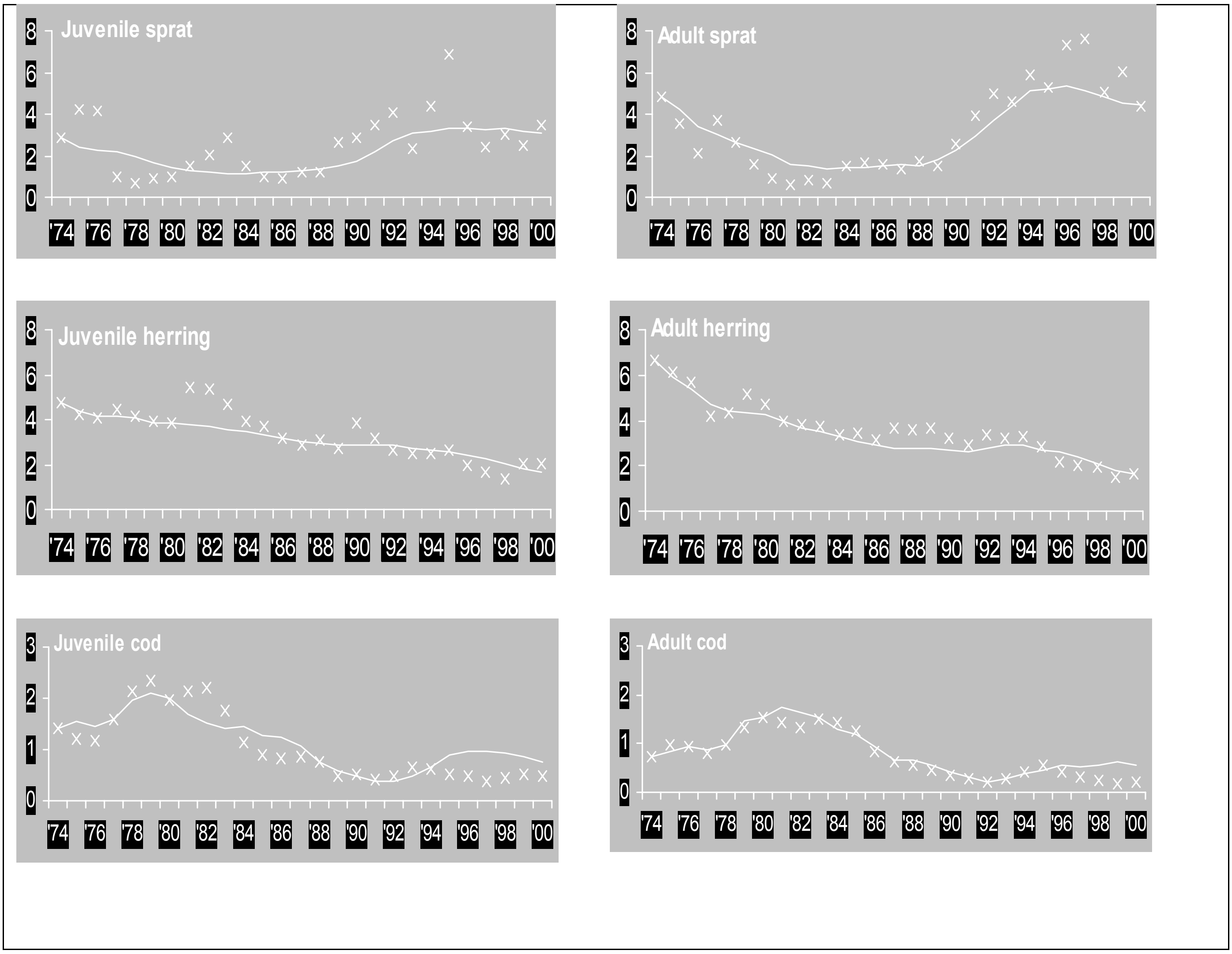


Fig. 6.1.10. Comparison of ECOSIM and MSVPA biomass estimates (MSVPA estimates taken from ICES 2001) (ECOSIM = −; MSVPA = x).

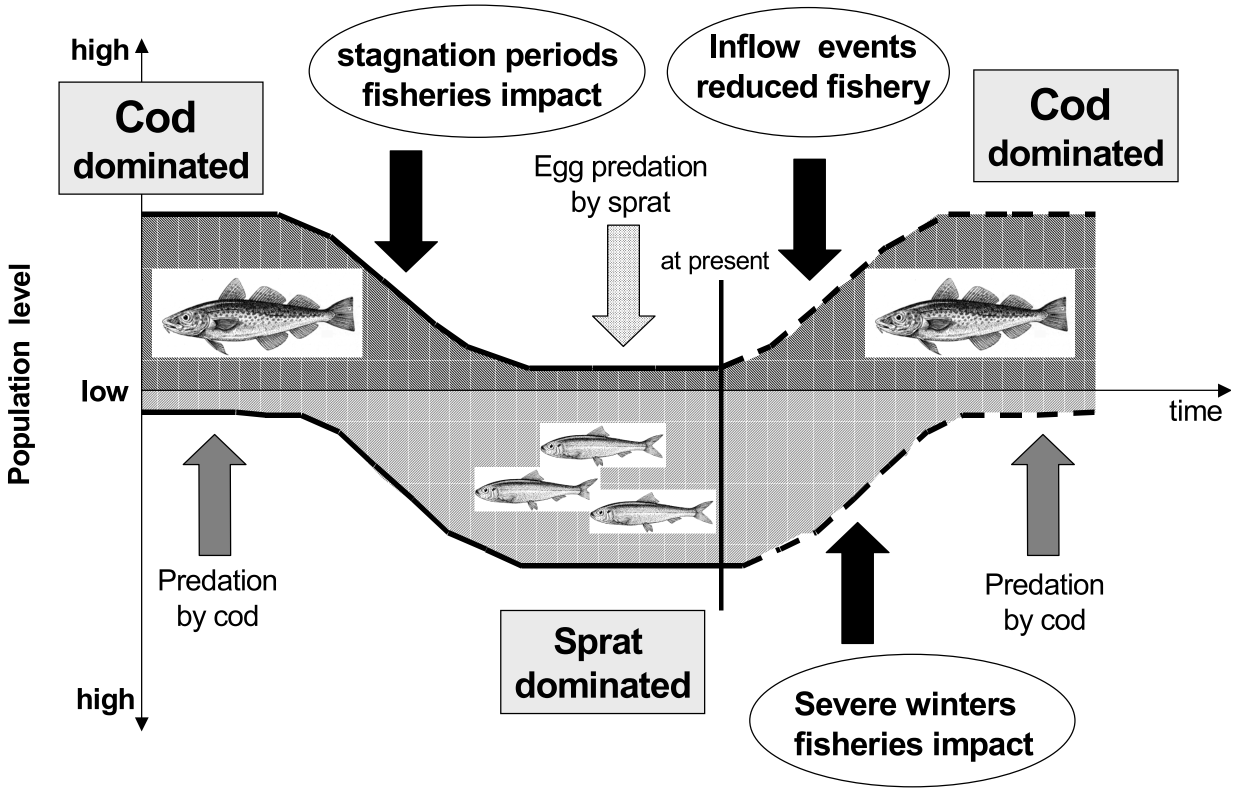


Fig. 6.1.11. Schematic presentation of processes stabilizing a cod or sprat dominated system in the Central Baltic. Note the vertical line represents the situation in the 2nd half of the 1990's with the regime shift taking place in late 1980's and early 1990's

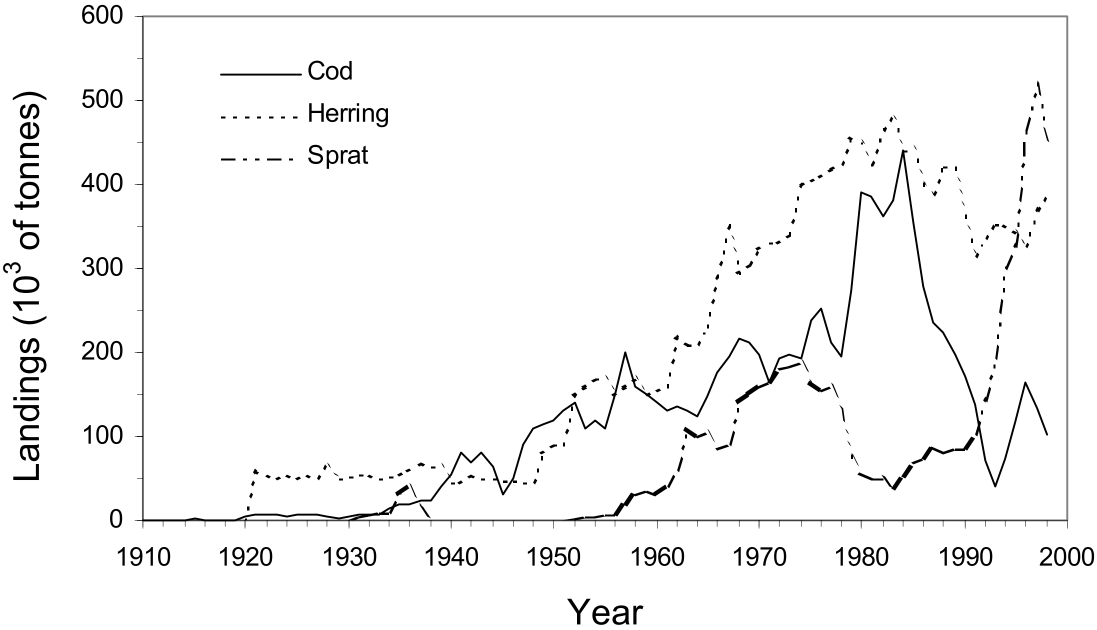


Figure 6.1.12. Commercial landings of cod, herring and sprat in the Baltic Sea (ICES Sub-divisions 22.-32) during the 20th century. Data from (Sparholt 1994) with updates from ICES (2000).

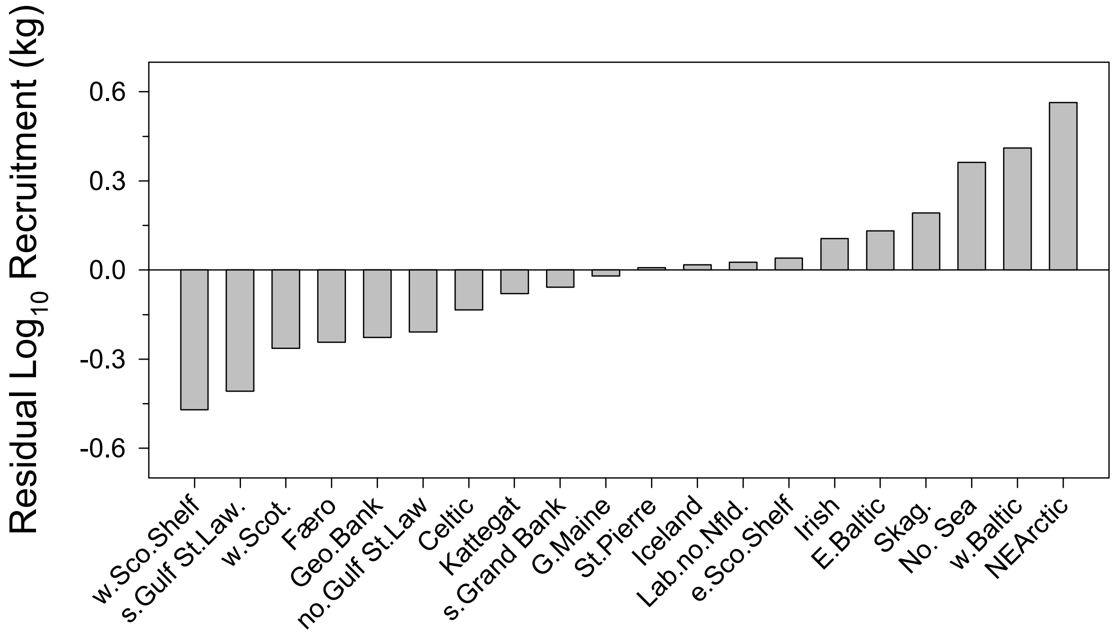


Figure 6.1.13. Mean residual log recruitment for 20 cod stocks in the North Atlantic. “Residual log recruitment” is the residual recruitment within each stock as estimated from a linear regression analysis of mean log recruitment vs mean log spawner biomass data for all 20 stocks. The recruitment data have been standardized to lifetime recruitment (Myers et al., 1996).

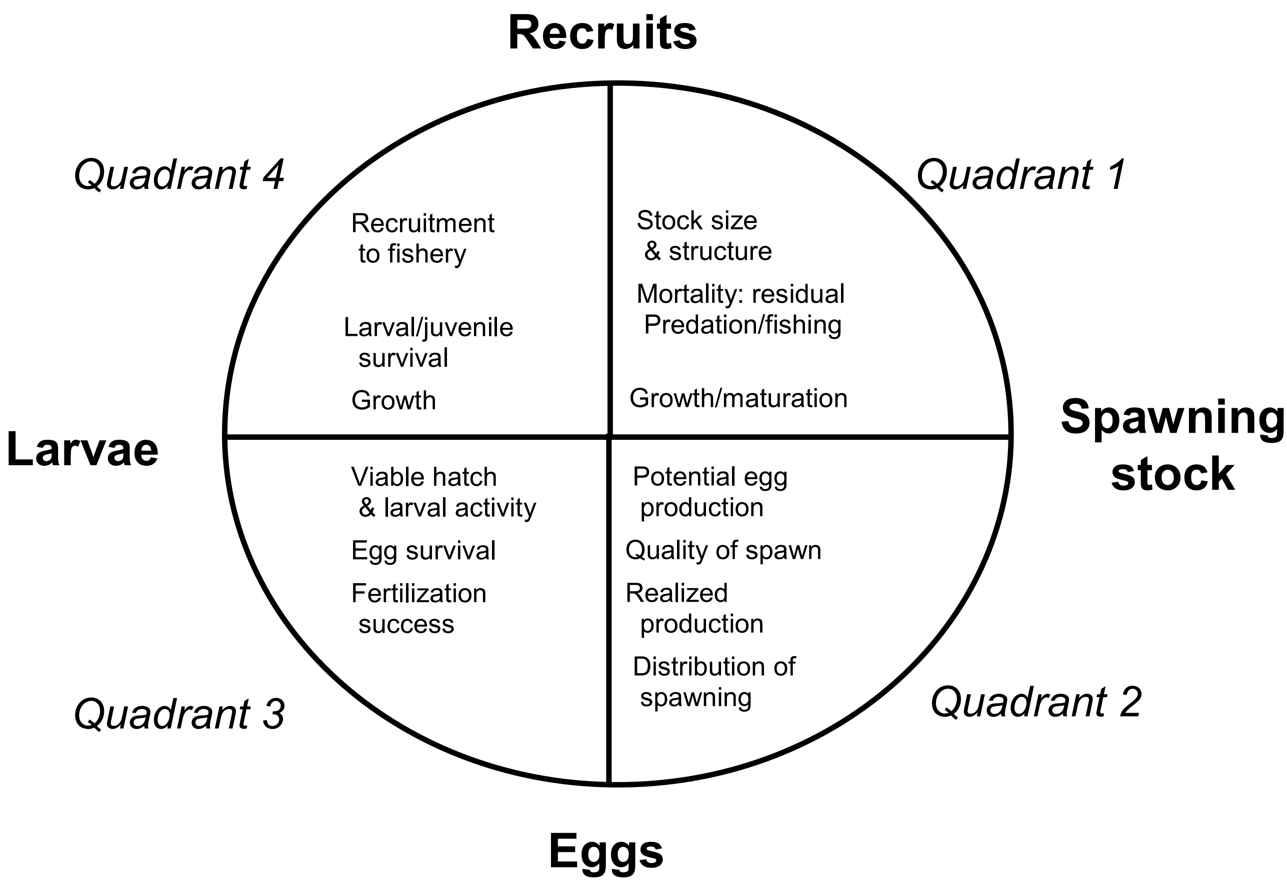


Fig. 6.1.14. The life cycle of fish with different processes affecting developmental success from one stage to the next (in clockwise direction), based on Paulik's multi-stage spawner recruit relationship (Paulik 1973) modified after Ulltang (1996).

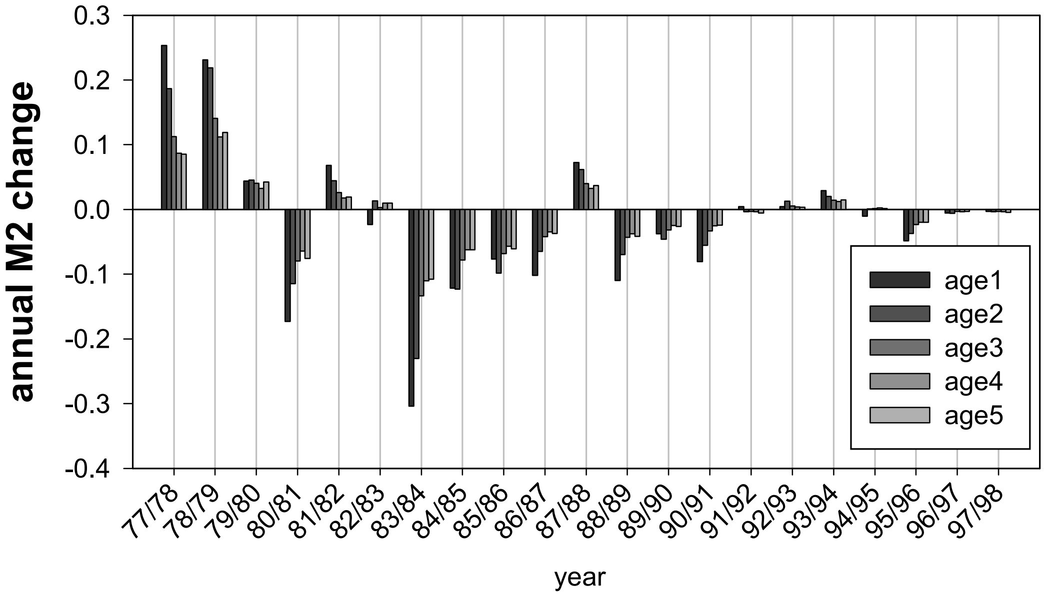


Fig. 6.1.15. Annual change in predation mortality rates (M2; per year) of Central Baltic sprat according to age-group as derived from MSVPA runs.

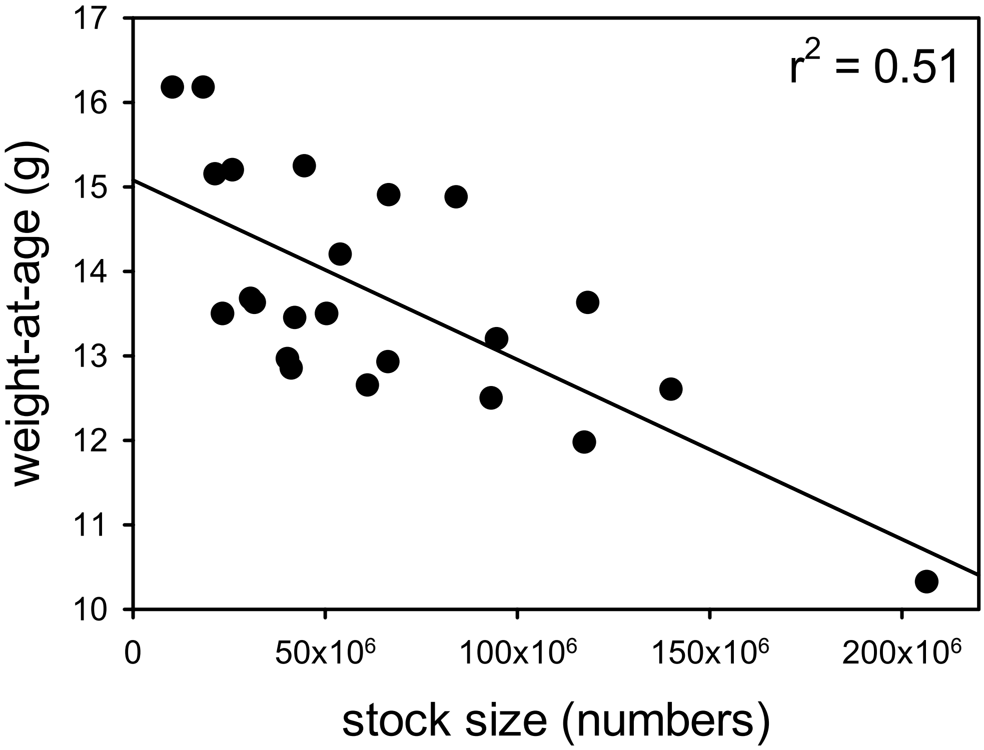


Fig. 6.1.16. Relationship between average weight at age 2-5 and stock size of sprat in the Baltic (from ICES, 2000).

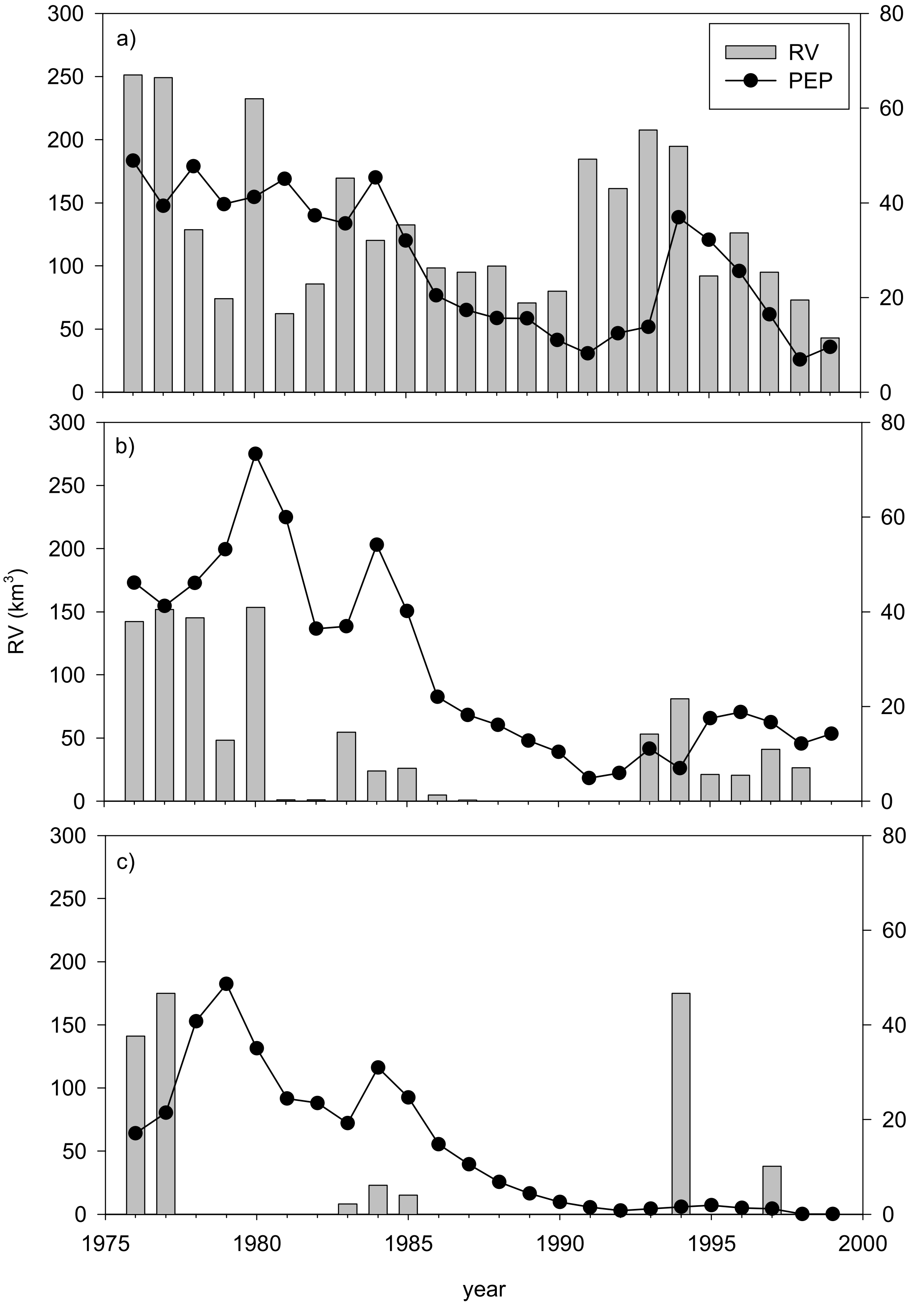


Fig. 6.1.17. Reproductive volume (RV) of cod eggs during main spawning seasons 1976-1999 and potential egg production of Central Baltic cod (PEP) in ICES Subdivision 25 (a), 26 (b) and 28 (c).

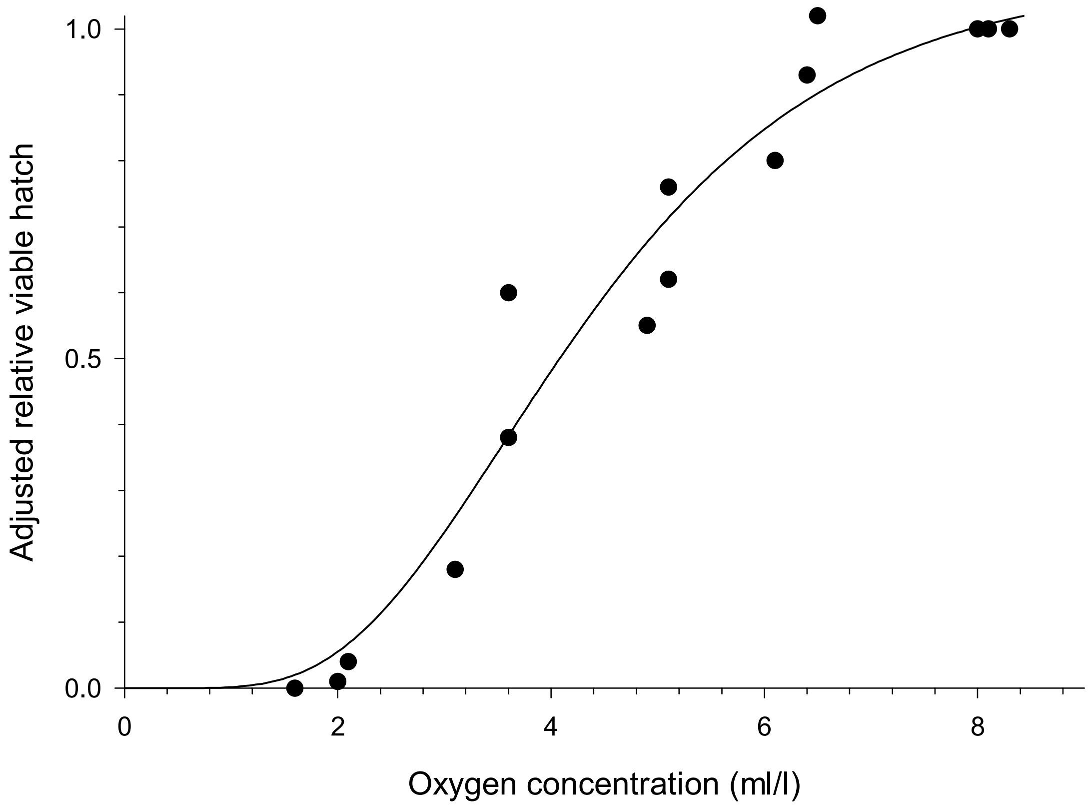


Fig. 6.1.18. Adjusted relative viable hatch of cod eggs at different levels of oxygen concentration during egg incubation; $r^2 = 0.95$.

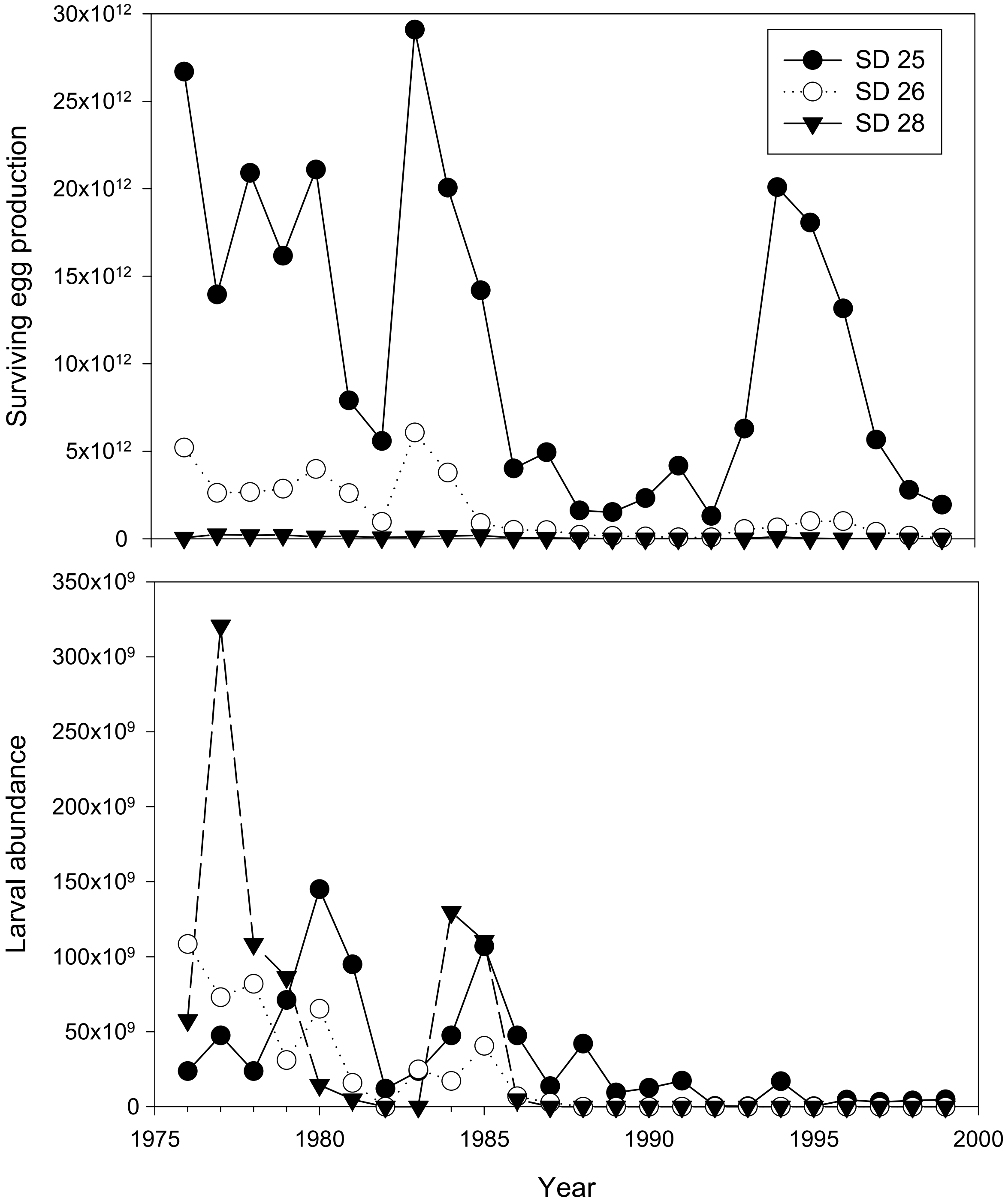


Fig. 6.1.19. Predicted surviving potential cod egg production in different Sub-divisions (a) and corresponding larval abundance (b).

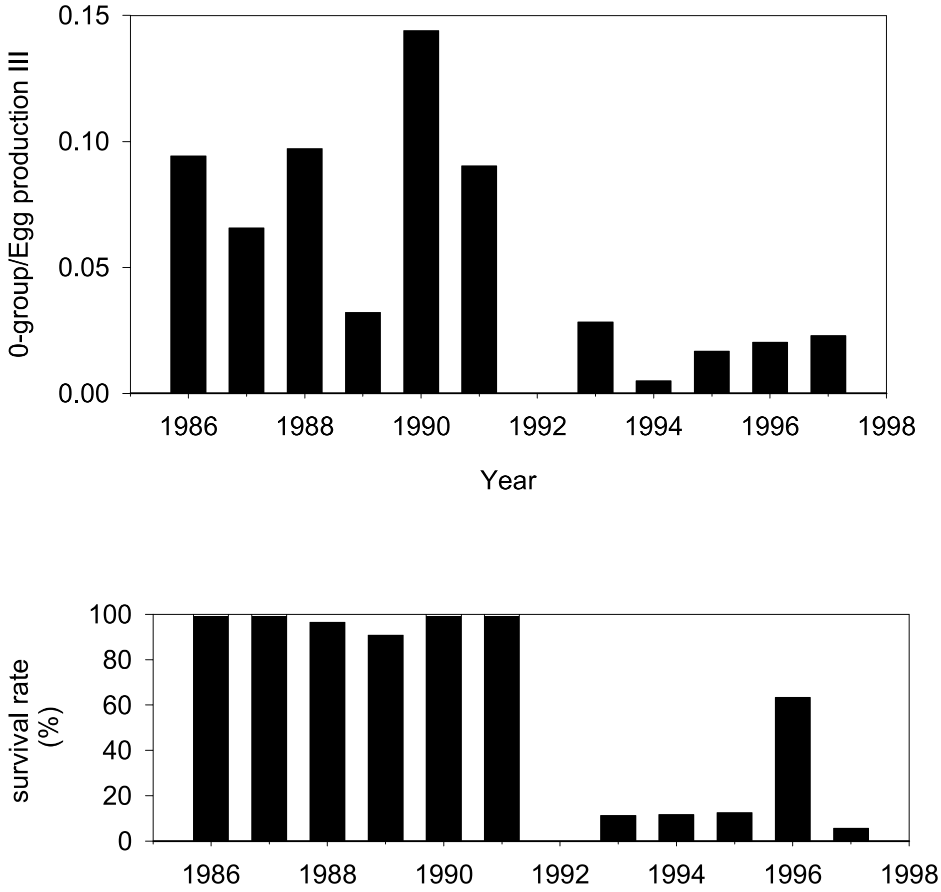


Fig. 6.1.20. Interannual survival of cod larvae from observations (recruitment at age 0 per unit of advanced egg stage production at main spawning time; upper panel) and simulated by the coupled tropho/hydrodynamic model (lower panel; no prey data for simulations in 1992).

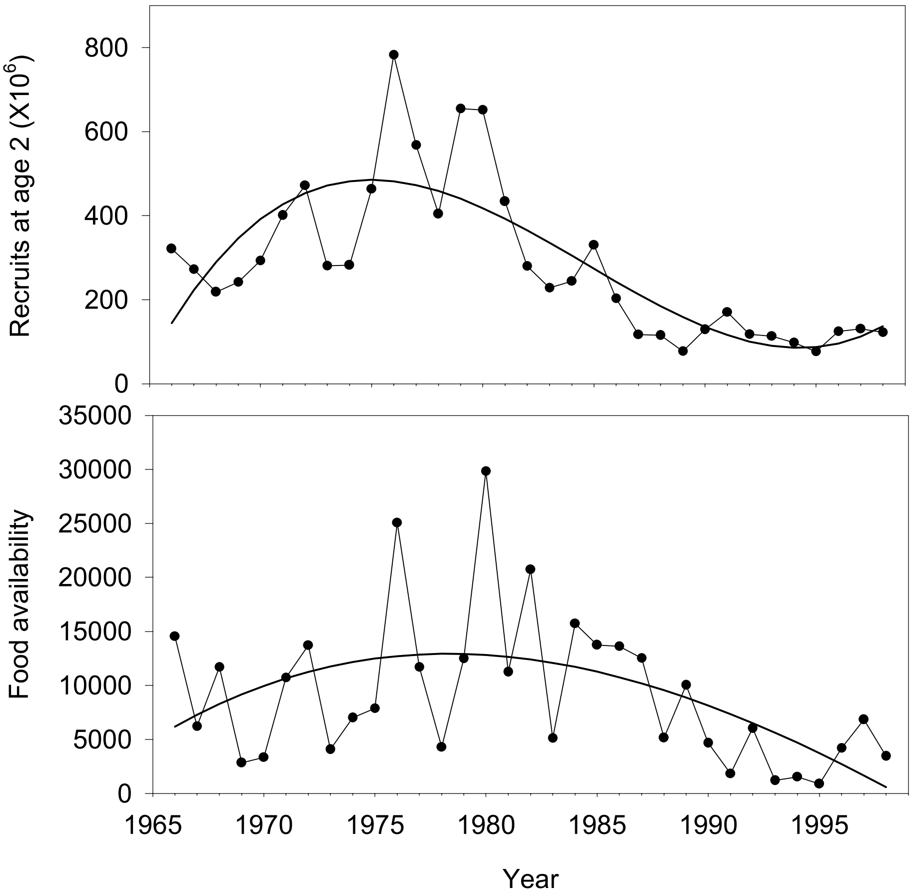


Fig. 6.1.21. Time series of recruitment of Baltic cod (shifted to the year of origin) from VPA (upper panel) and feeding potential of *P. elongatus* (lower panel) with corresponding long-term trends (solid lines).

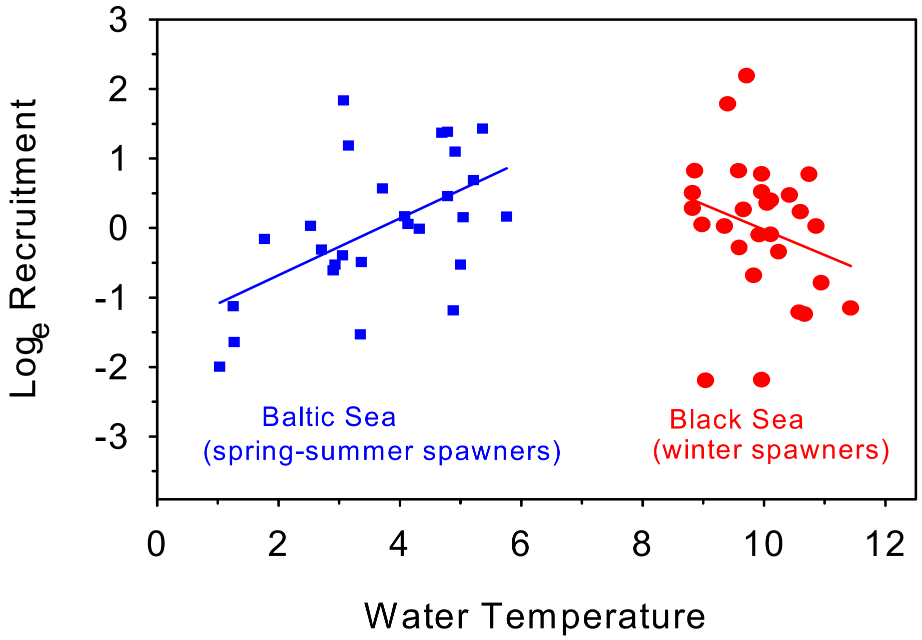


Fig. 6.1.22. Geographical comparison of the effects of water temperature on recruitment of sprat in the Baltic (squares) and Black Seas (circles). Recruitment data have been loge transformed and standardized. Temperatures were measured during main spawning times in the year of birth. The regression model for Baltic Sea sprat recruitment is ln R_{stand} = -1.493 + 0.41*T (R^2adj. = 28%, P = 0.0029, SE_{est} = 0.851, DW = 2.23).

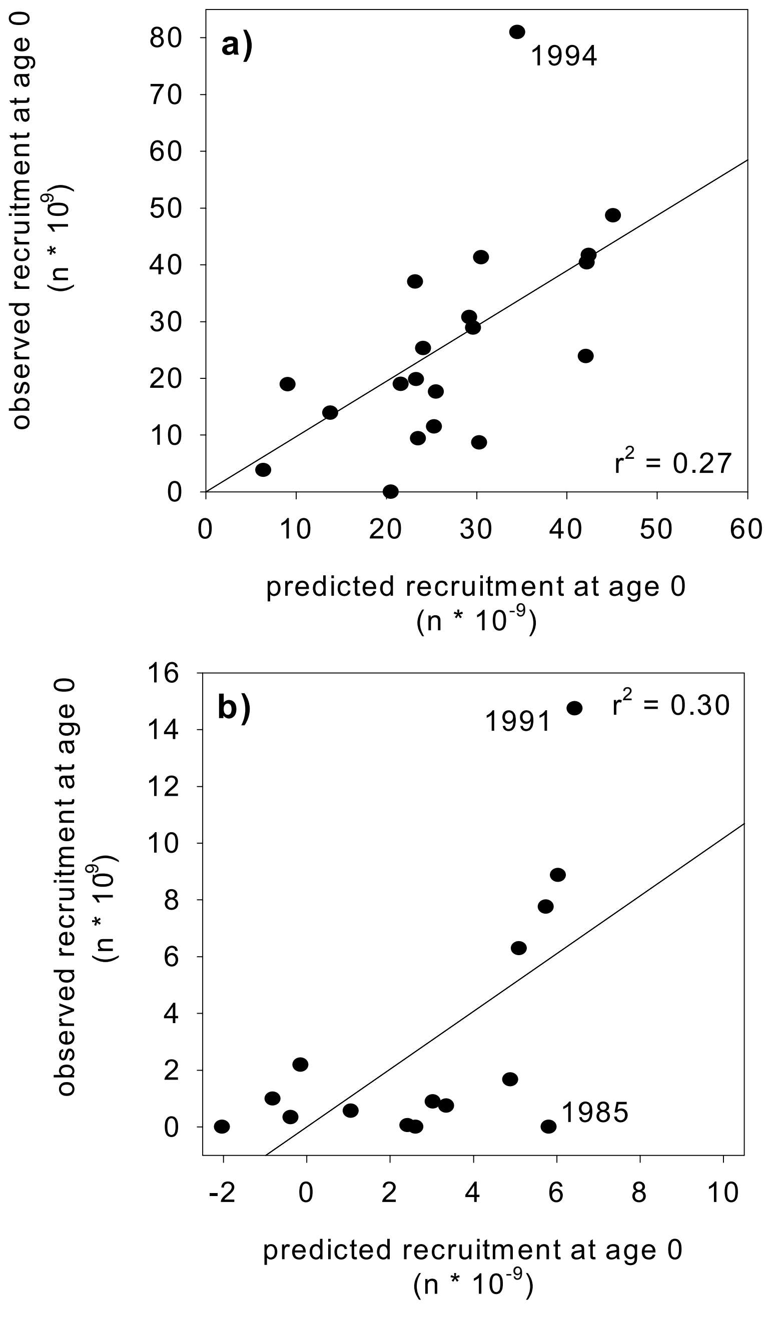


Fig. 6.1.23. Sprat recruitment at age 0 in Sub-division 26 (determined by MSVPA) and predicted by a multiple linear regression model utilizing larval abundance and temperature in the intermediate water in May/June as independent variables (a); sprat recruitment at age 0 in Sub-division 28 (determined by hydroacoustic surveys) and predicted by a multiple linear regression model utilizing larval abundance and temperature in the intermediate water in May/June as independent variables (b).

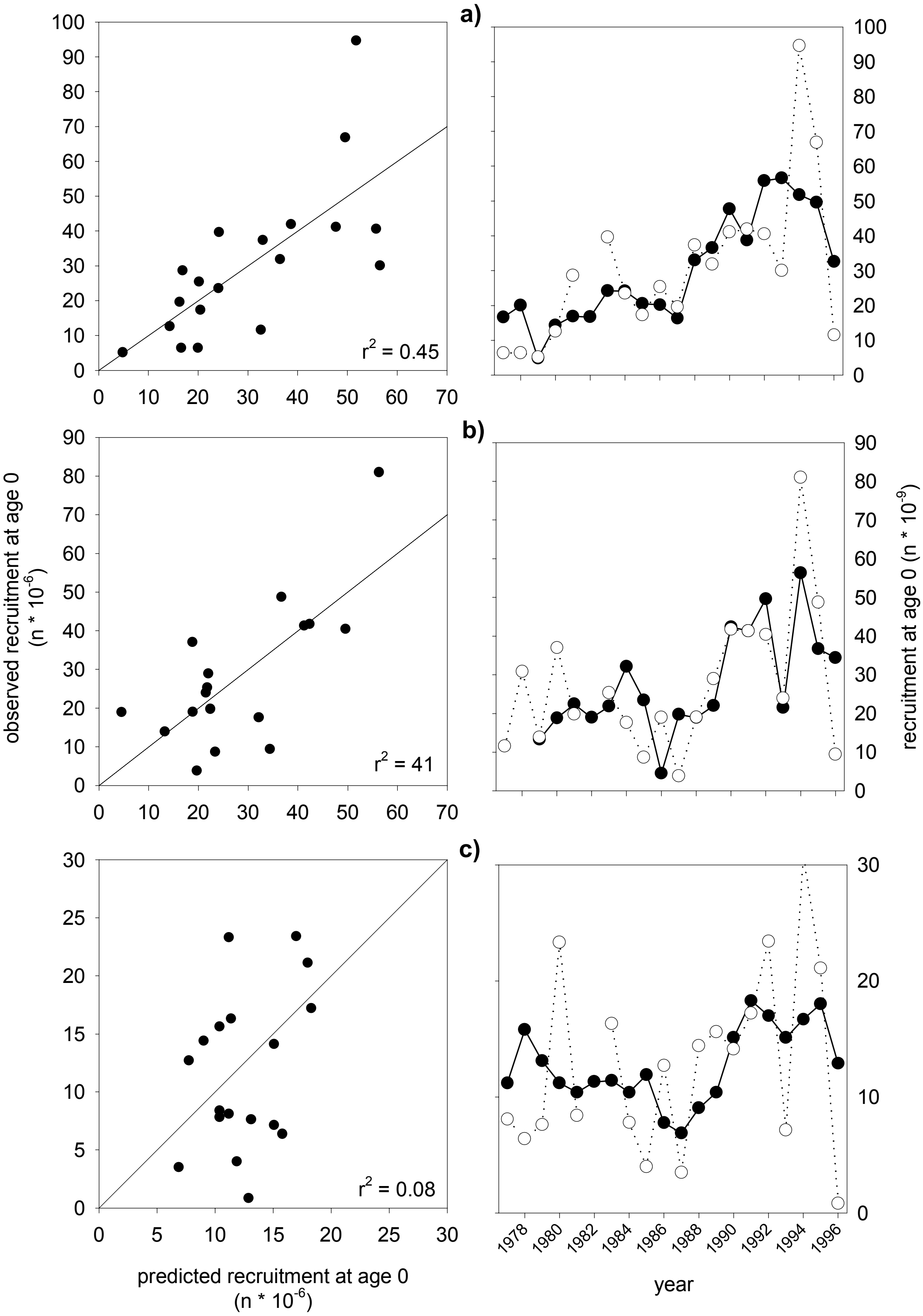


Fig. 6.1.24. Sprat recruitment at age 0 determined by MSVPA and predicted by a multiple linear regression model utilizing SSB and temperature in the intermediate water as independent variables for Sub-division 25 (a); sprat recruitment as above adding growth anomaly as further independent variable for Sub-division 26 (b); sprat recruitment predicted as in Sub-division 25 for Sub-division 28 (c); including time trends of observed (dotted lines and open circles) and predicted values (solid lines and circles) for all three statistical models (right panels).

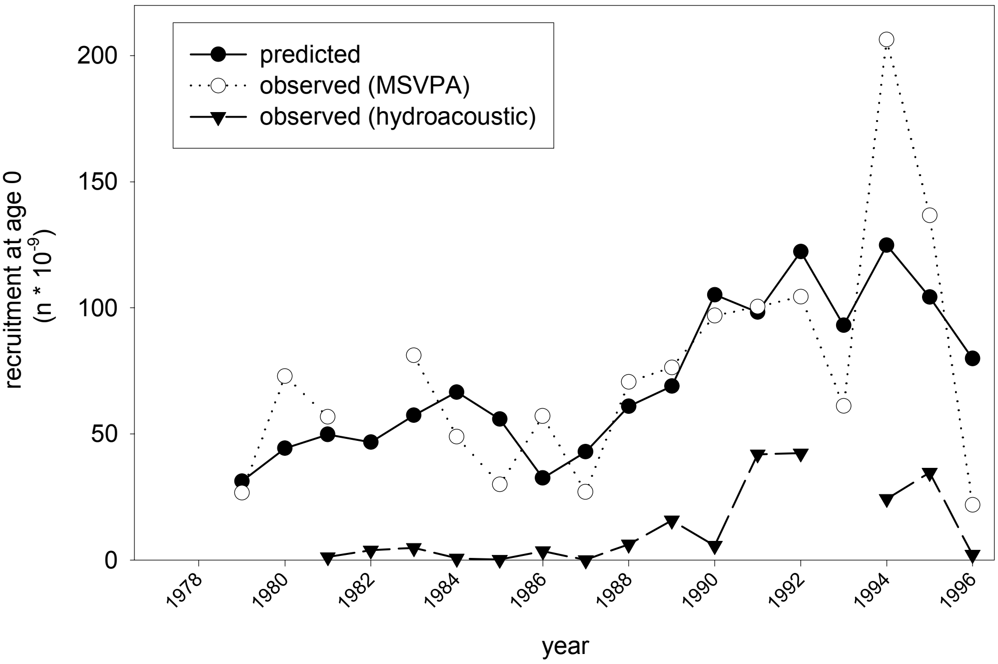


Fig. 6.1.25. Sprat recruitment at age 0 determined by MSVPA and international hydroacoustic survey in combined Sub-division 25, 26 and 28 in comparison to predicted recruitment based on SSB, temperature and growth anomaly (latter only in Sub-division 26).

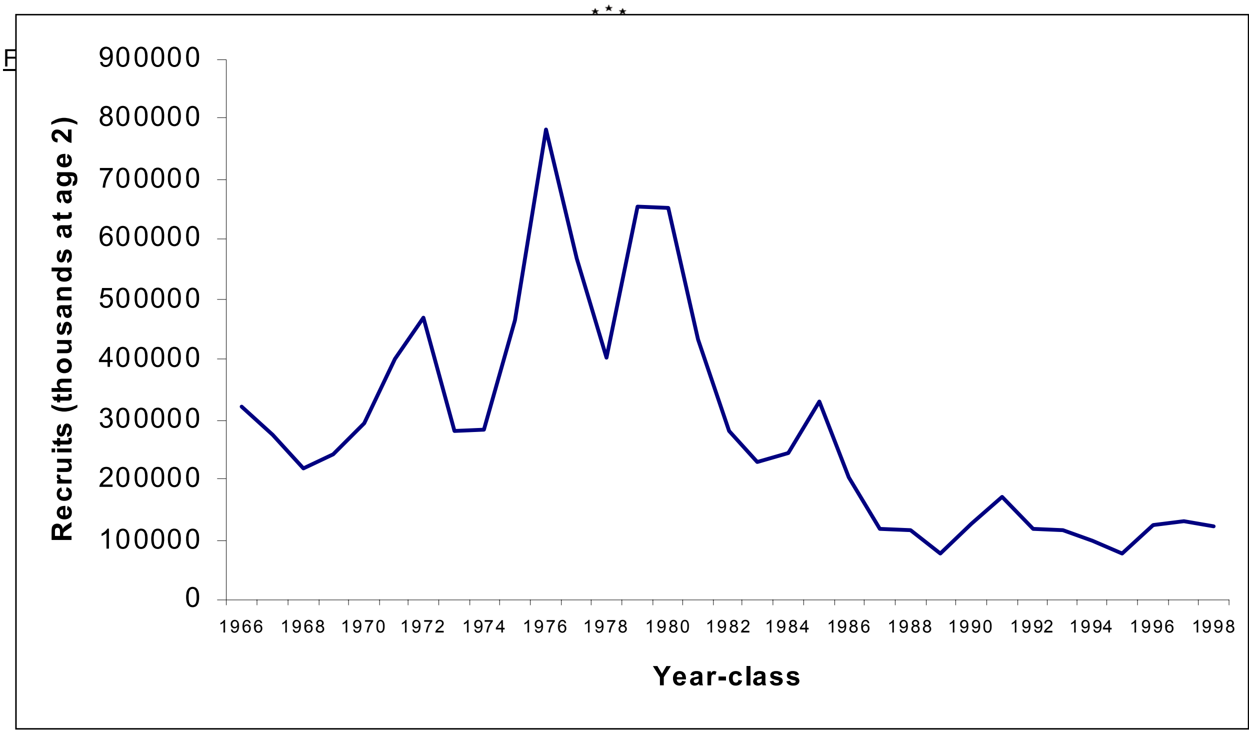


Fig. 6.1.26. Eastern Baltic cod recruitment.

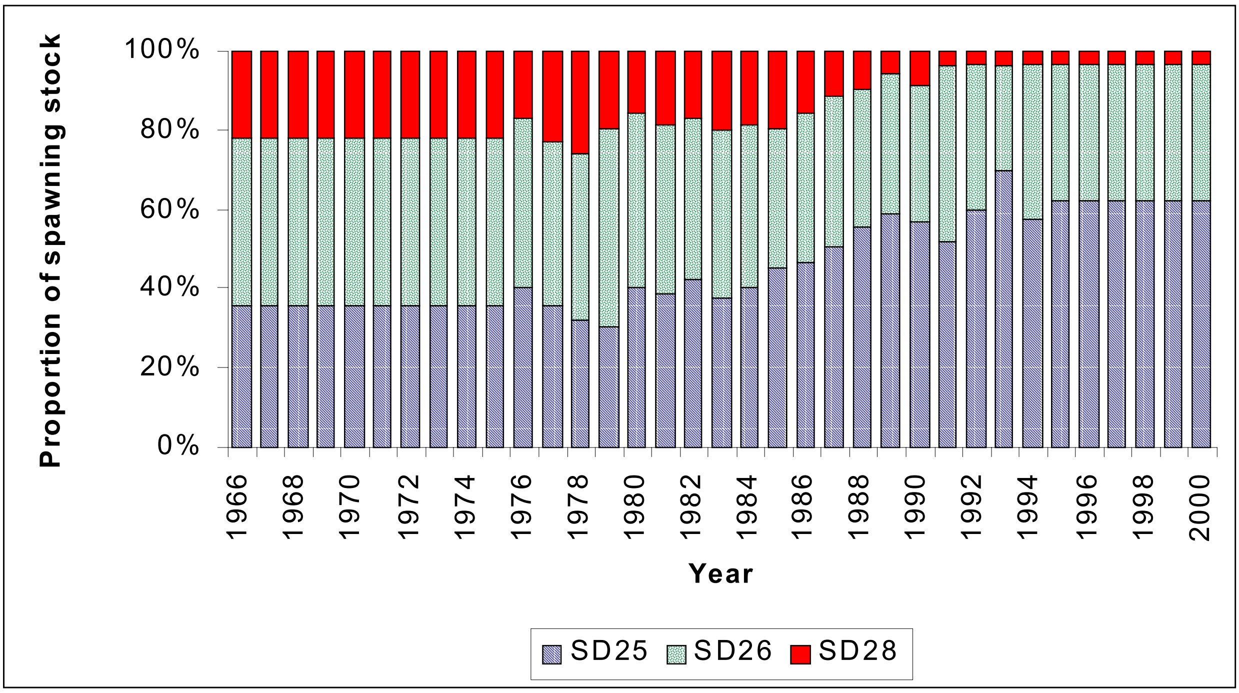


Fig. 6.1.27. Estimated distribution of spawning stock of eastern Baltic cod between sub-divisions.

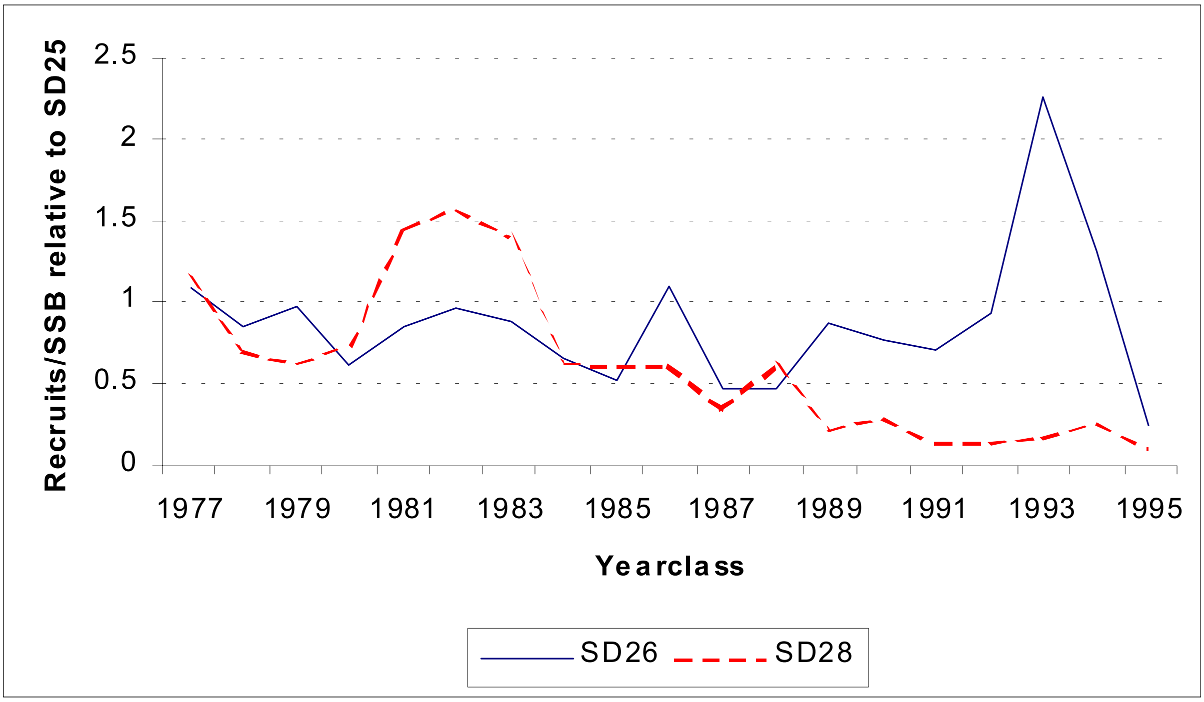


Fig. 6.1.28. Productivity (in recruits/SSB) of spawning in sub-divisions 26 and 28 relative to sub-division 25.

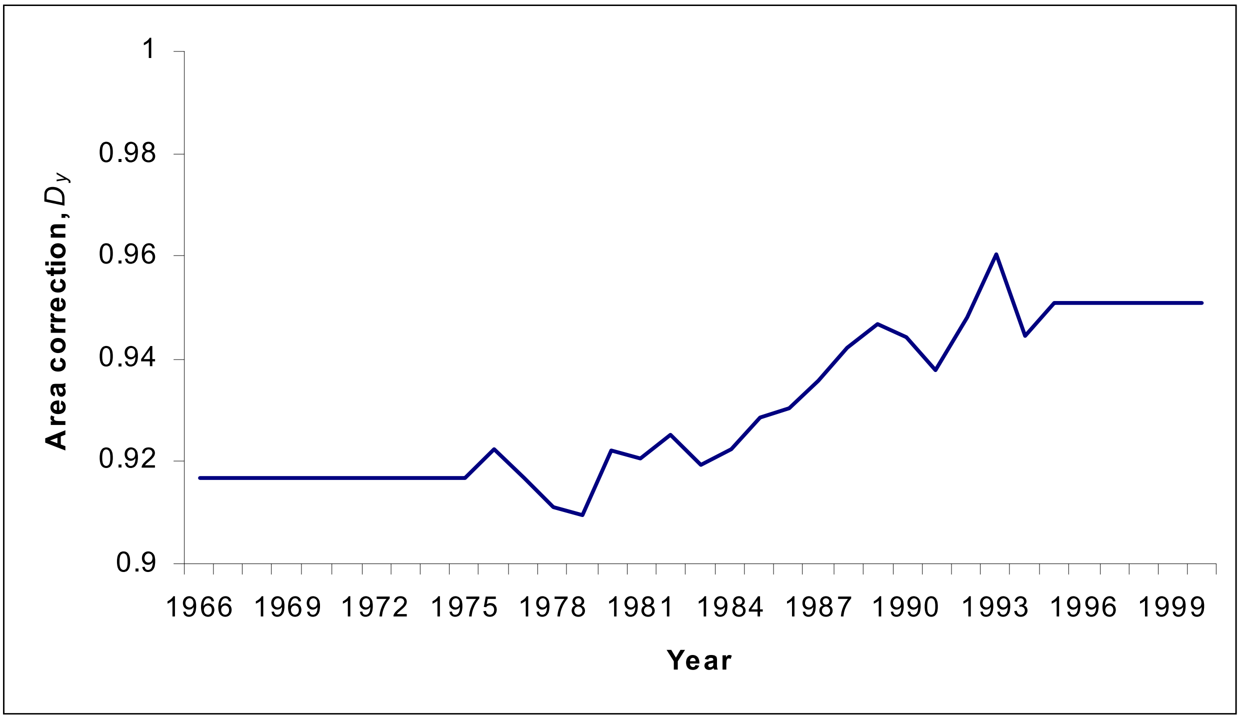


Fig. 6.1.29. Area corrections, *Dy*, applied to SSB to account for dsitribution between spawning areas.

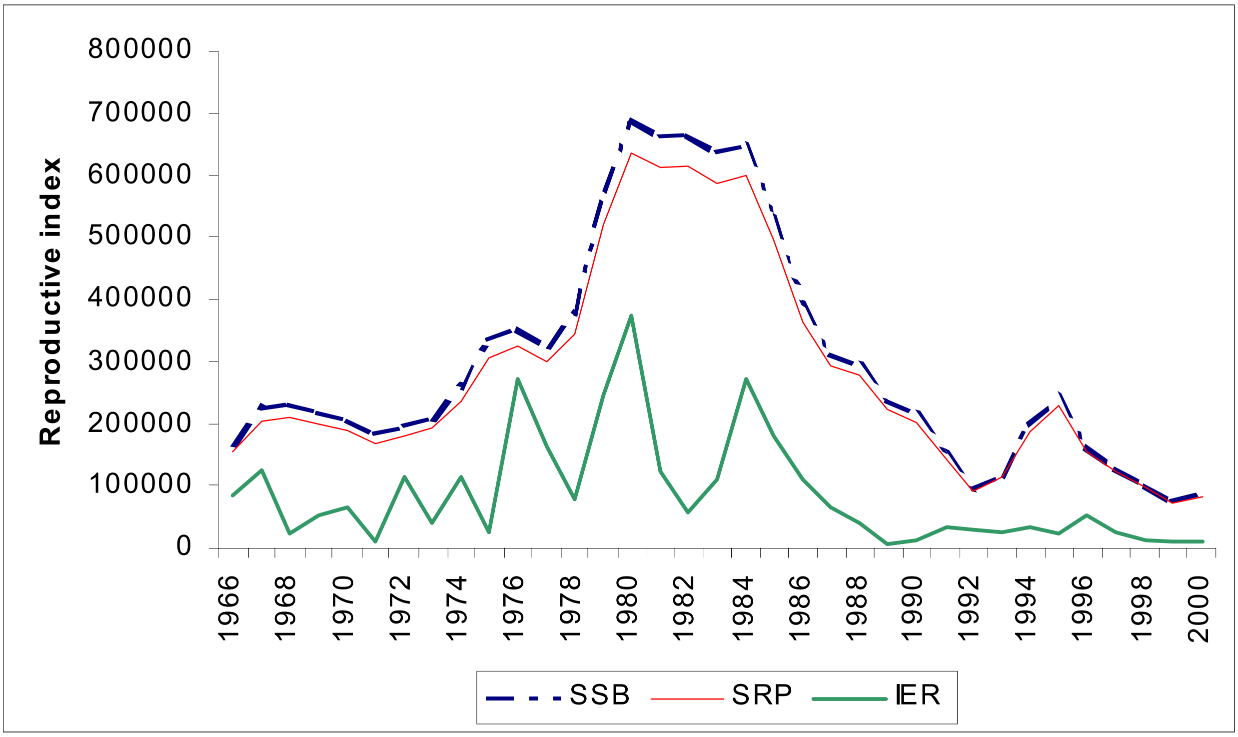


Fig. 6.1.30. Reproductive indices for Eastern Baltic cod. The indices shown are spawning stock biomass (SSB), the area-corrected index used to estimate stock reproductive potential (SRP) and the derived index of effective reproduction (IER).

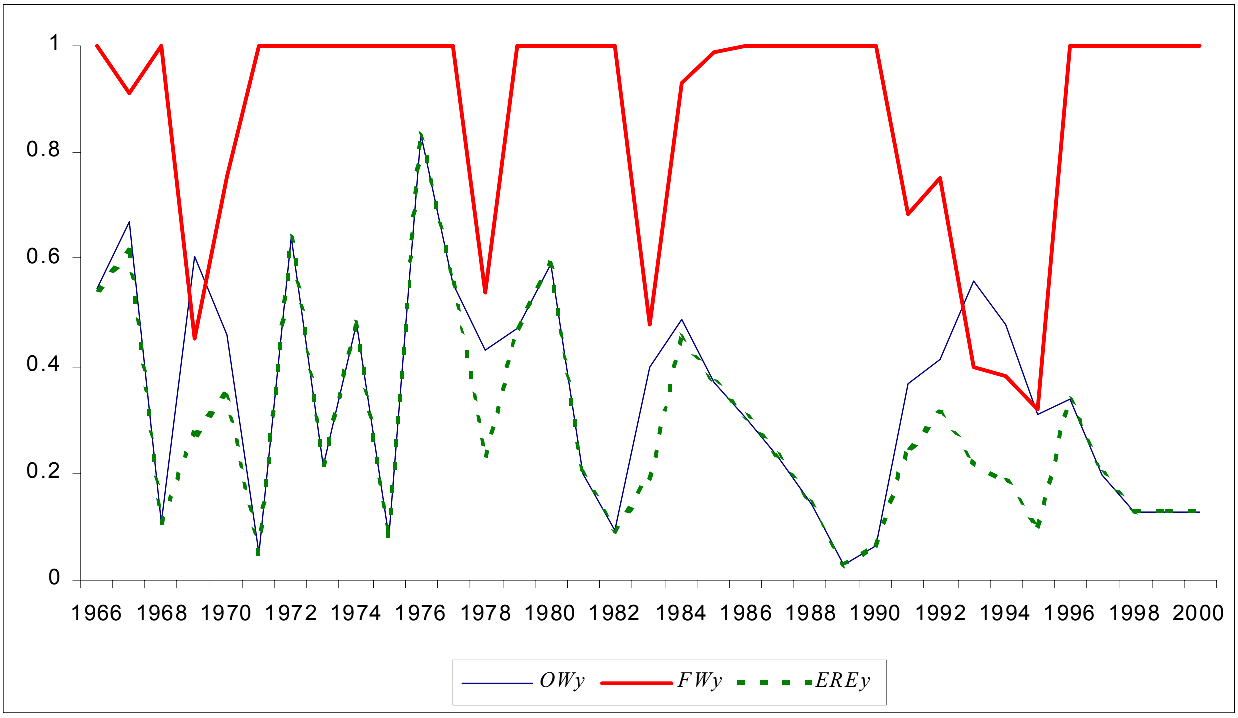


Fig. 6.1.31. Estimated weightings for oxygen conditions (OW_y) and food availability (FW_y) and overall indices of effective reproductive environment (ERE_y).

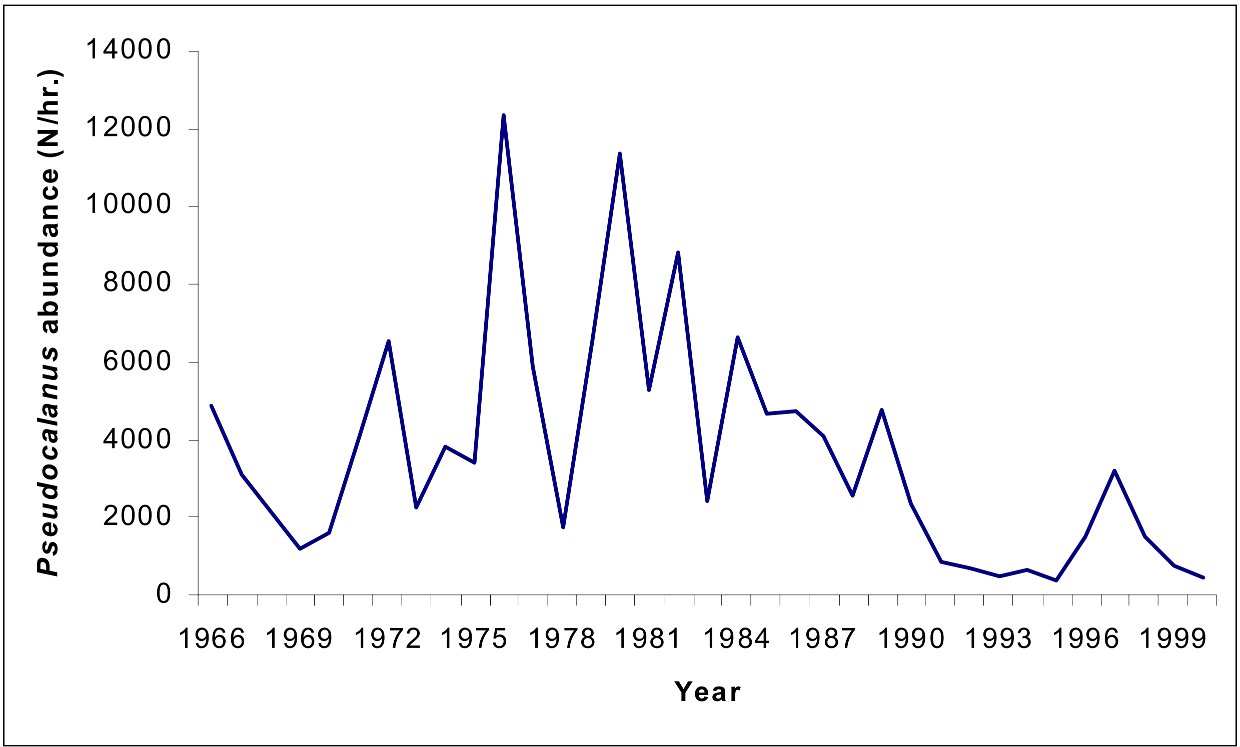


Fig. 6.1.32. Abundance indices of nauplii of the copepod *Pseudocalanus elongatus* in the Eastern Baltic.

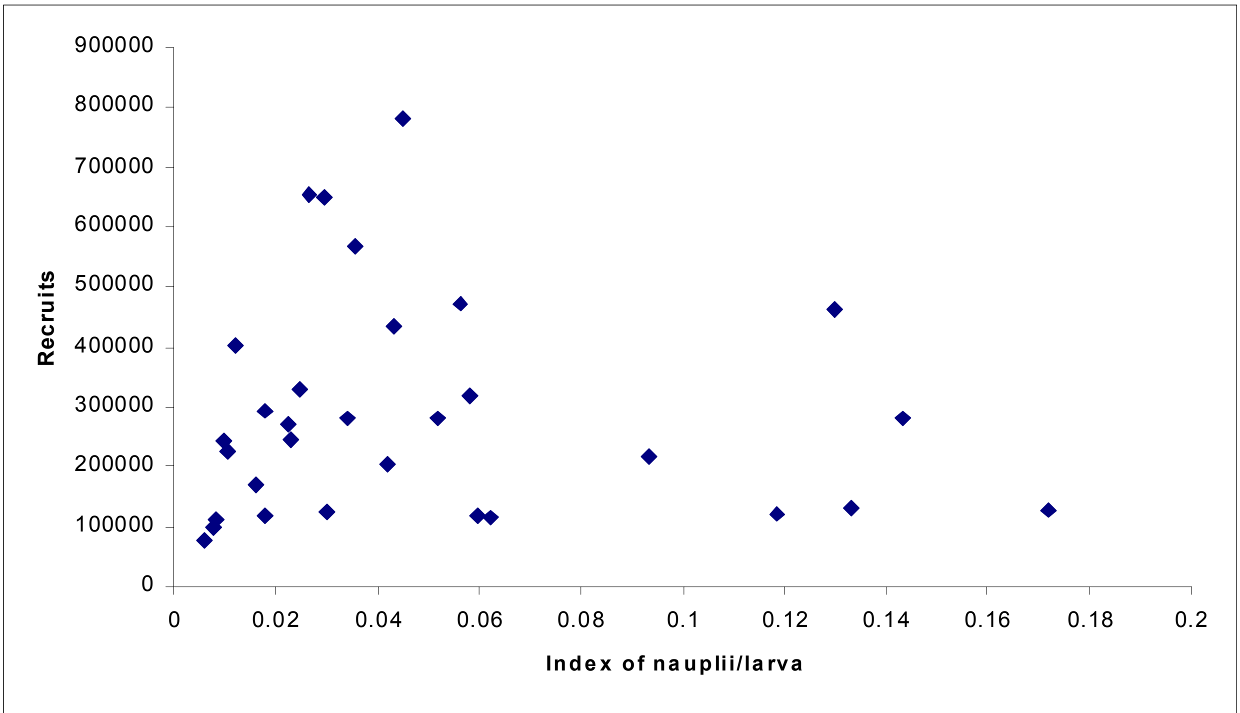


Fig. 6.1.33. The relationship between yearclass strength and relative food availability.

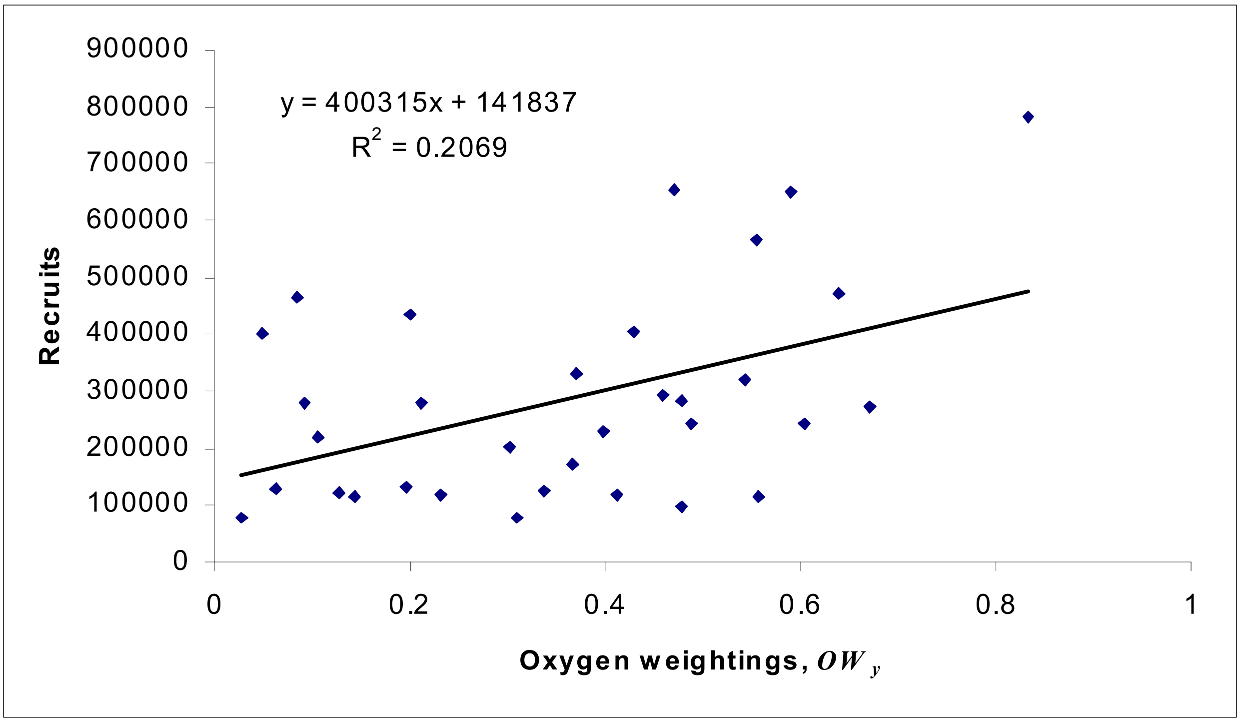


Fig. 6.1.34. The relationship between yearclass strength and oxygen weightings.

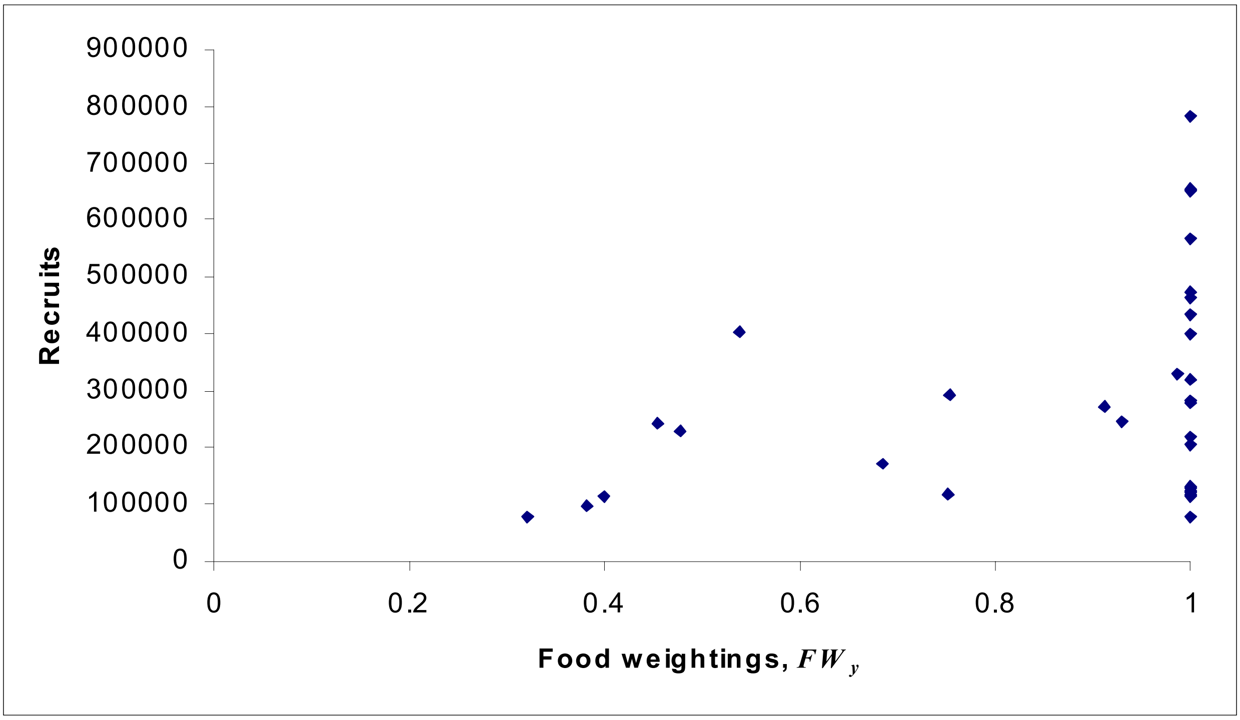


Fig. 6.1.35 The relationship between yearclass strength and food weightings.

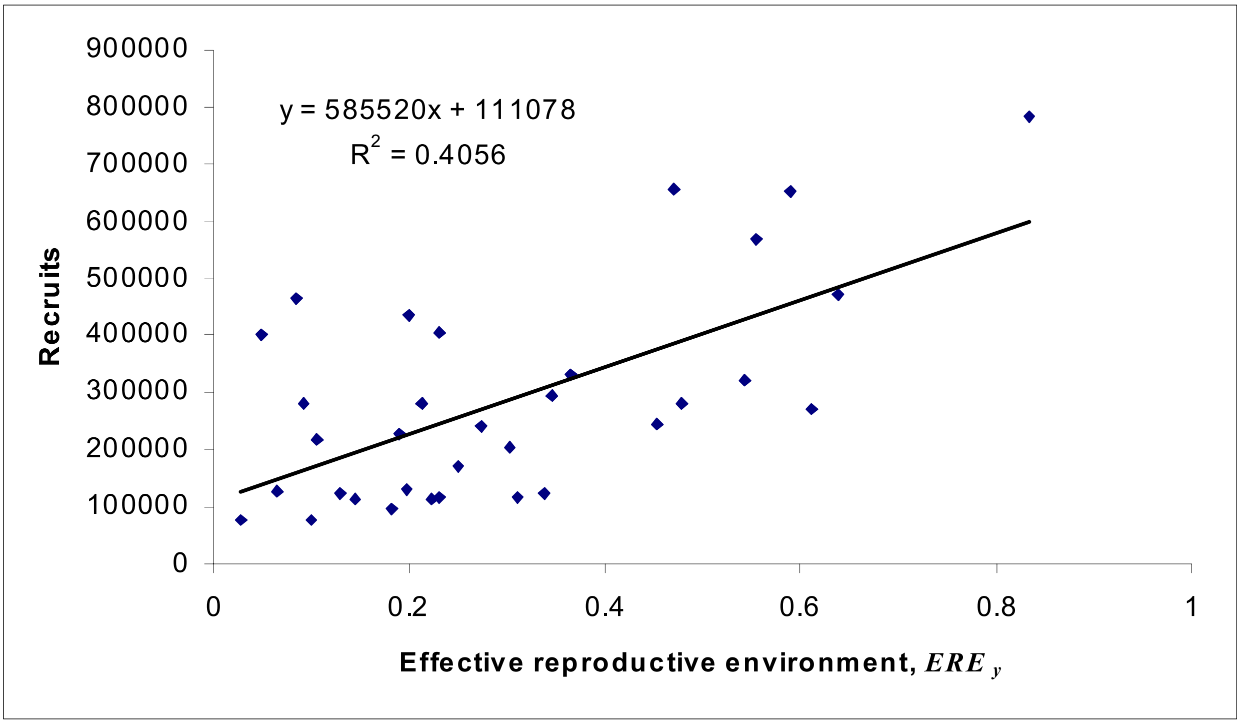


Fig. 6.1.36. The relationship between yearclass strength and effective reproductive environment.

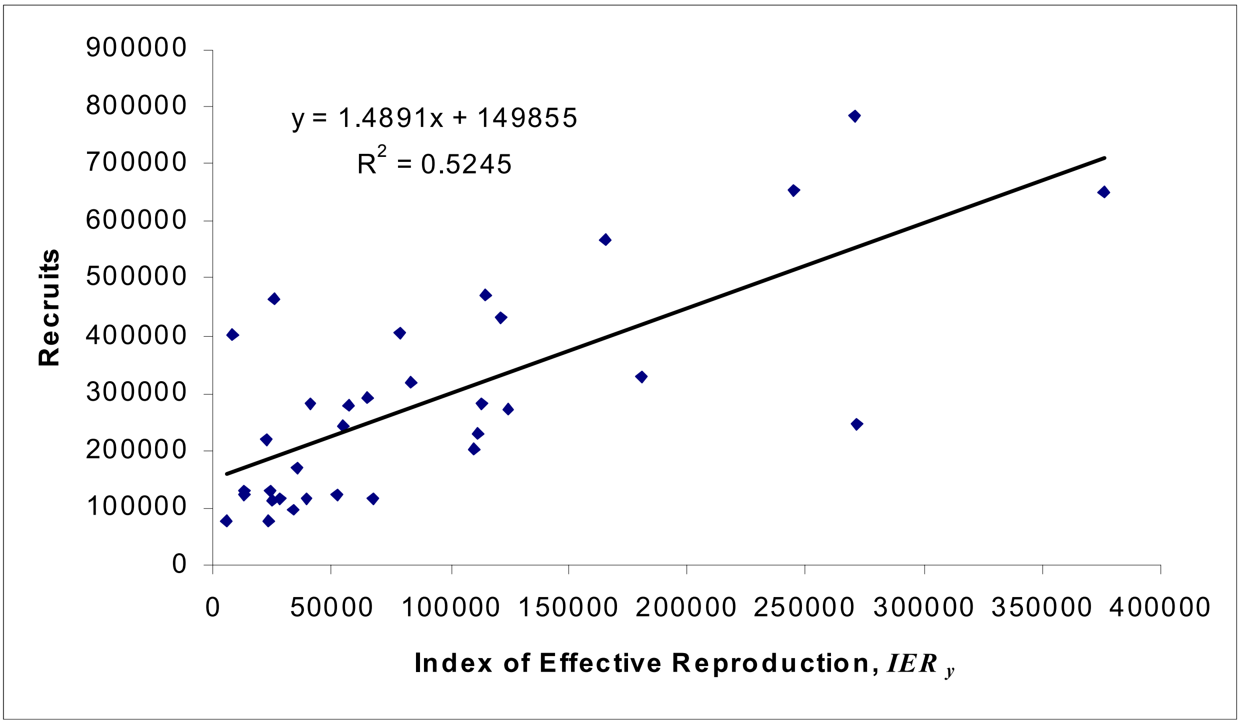


Fig. 6.1.37. The relationship between yearclass strength and the index of effective reproduction. A fitted regression is line to give an indication of the goodness of fit of a linear relationship.

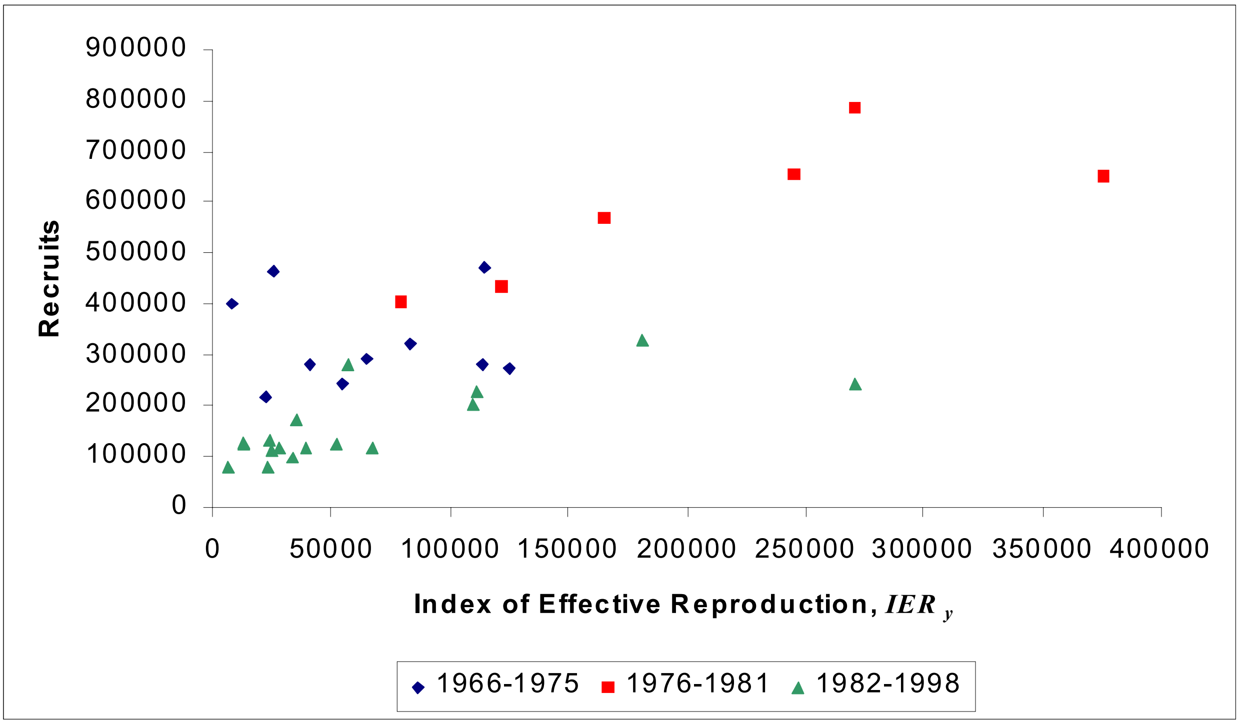


Fig. 6.1.38. The relationship between yearclass strength and the index of effective reproduction, showing yearclass estimates categorised into three time periods.

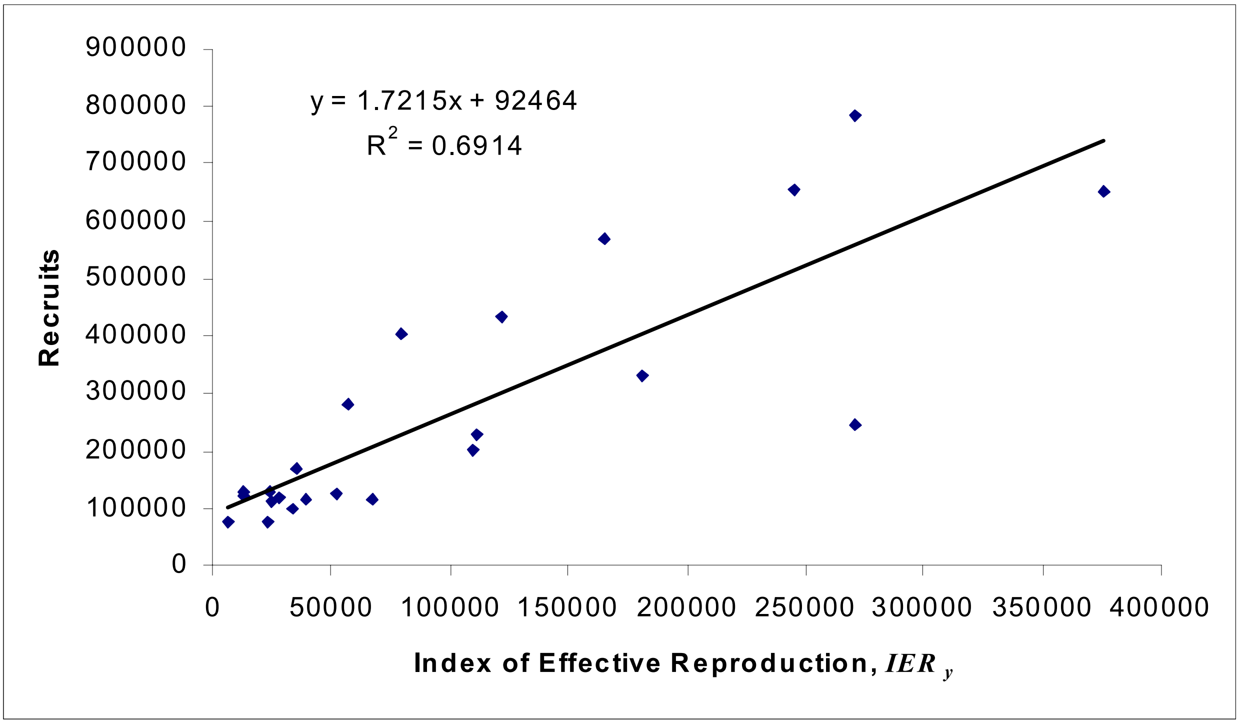


Fig. 6.1.39. The relationship between yearclass strength and the index of effective reproduction for yearclasses from 1976 onwards only. A fitted regression is line to give an indication of the goodness of fit of a linear relationship.

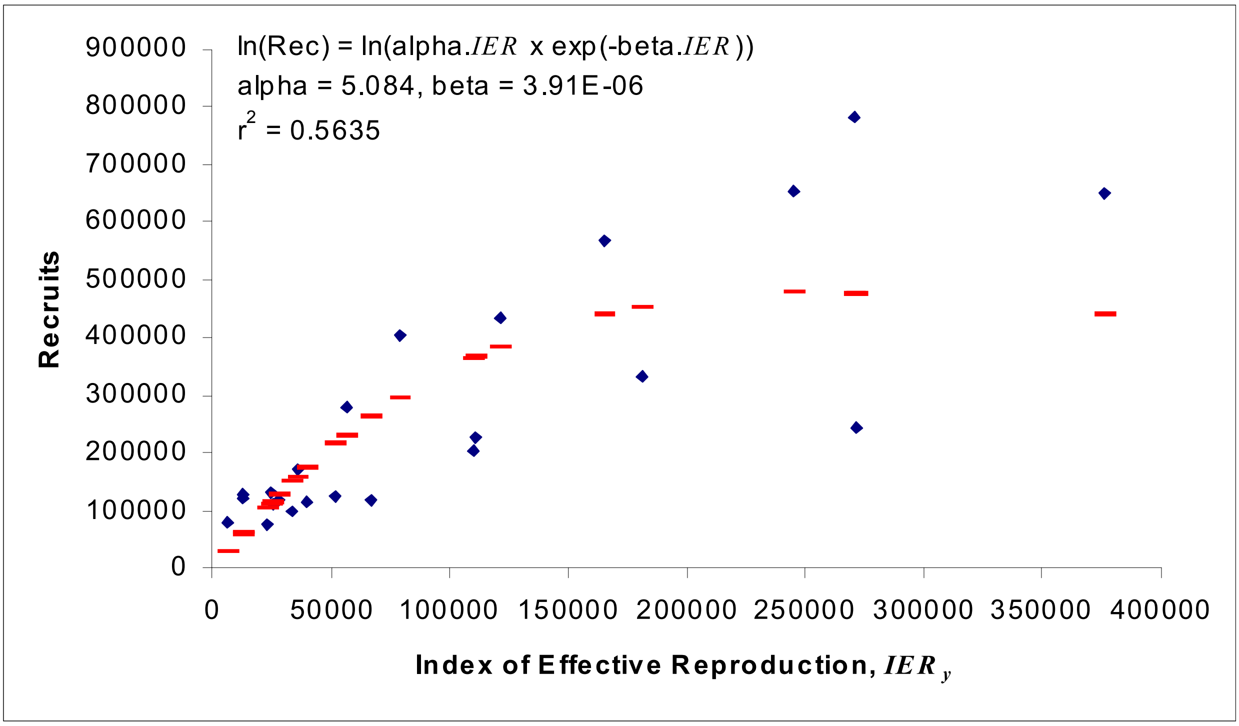


Fig. 6.1.40. The relationship between yearclass strength and the index of effective reproduction for yearclasses from 1976 onwards only. The dashed lines indicate the Ricker curve used to model recruitment.

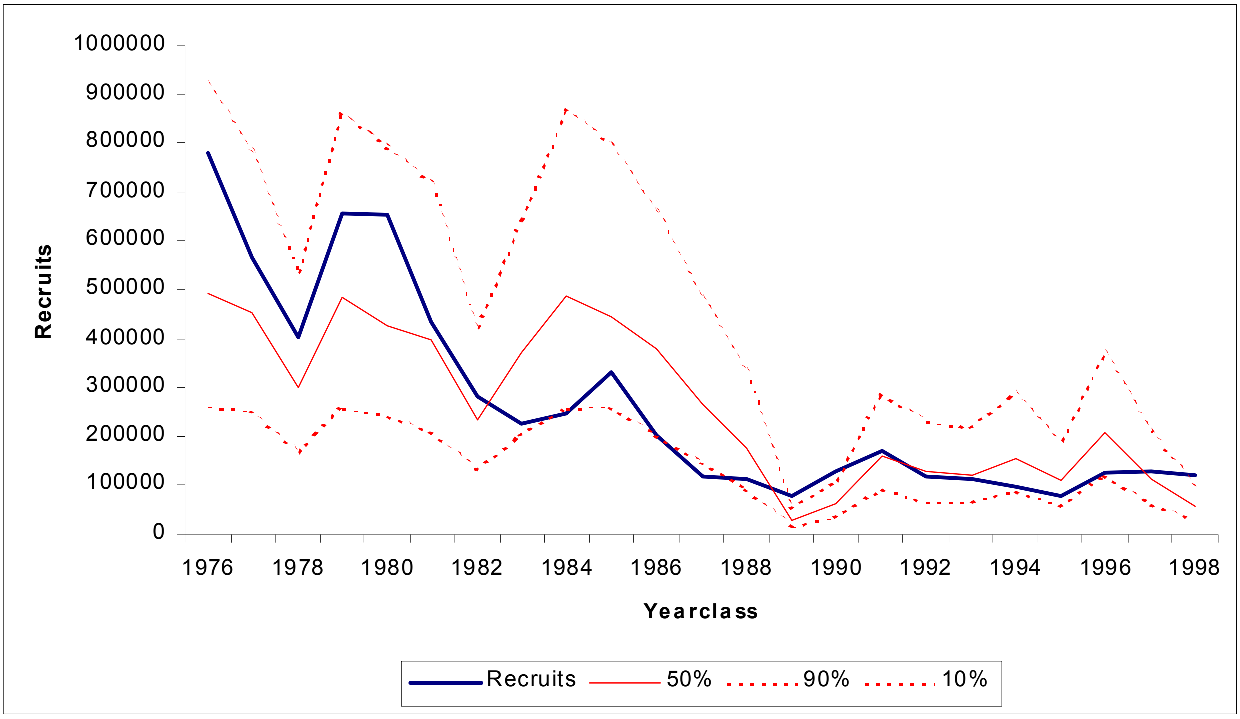
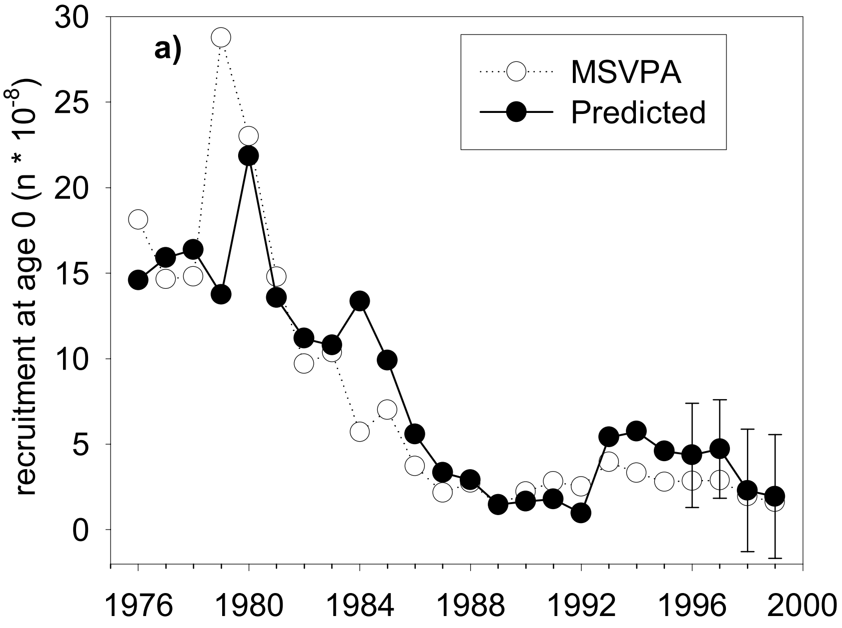


Fig. 6.1.41. A diagnostic plot for the fitted Ricker curve showing the observed recruitment estimates in comparison with the fitted values and the 10 and 90 percentiles of the fitted values.



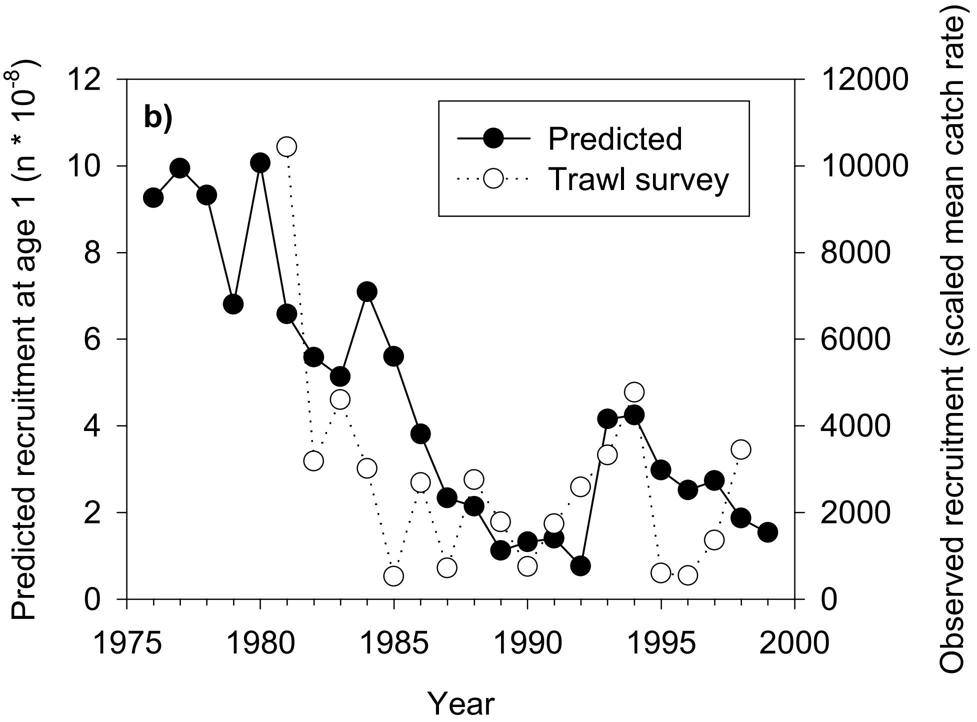


Fig. 6.1.42. Cod recruitment at age 0 in Sub-division 25, 26 and 28 combined (from MSVPA) and predicted by a multiple linear regression model utilising potential egg production by SSB corrected for egg consumption, oxygen content in the reproductive volume and larval transport as independent variables; parameter estimated from data series 1976-1995 and recruitment predicted for 1996-1999 with 95% confidence limits of the predicted means (a); cod recruitment at age 1 in Sub-divisions 25, 26 and 28 from 1st quarter bottom trawl survey, (scaled arithmetic mean catch rates) and predicted by above multiple linear regression model and applied predicted 0-group predation mortalities (b).

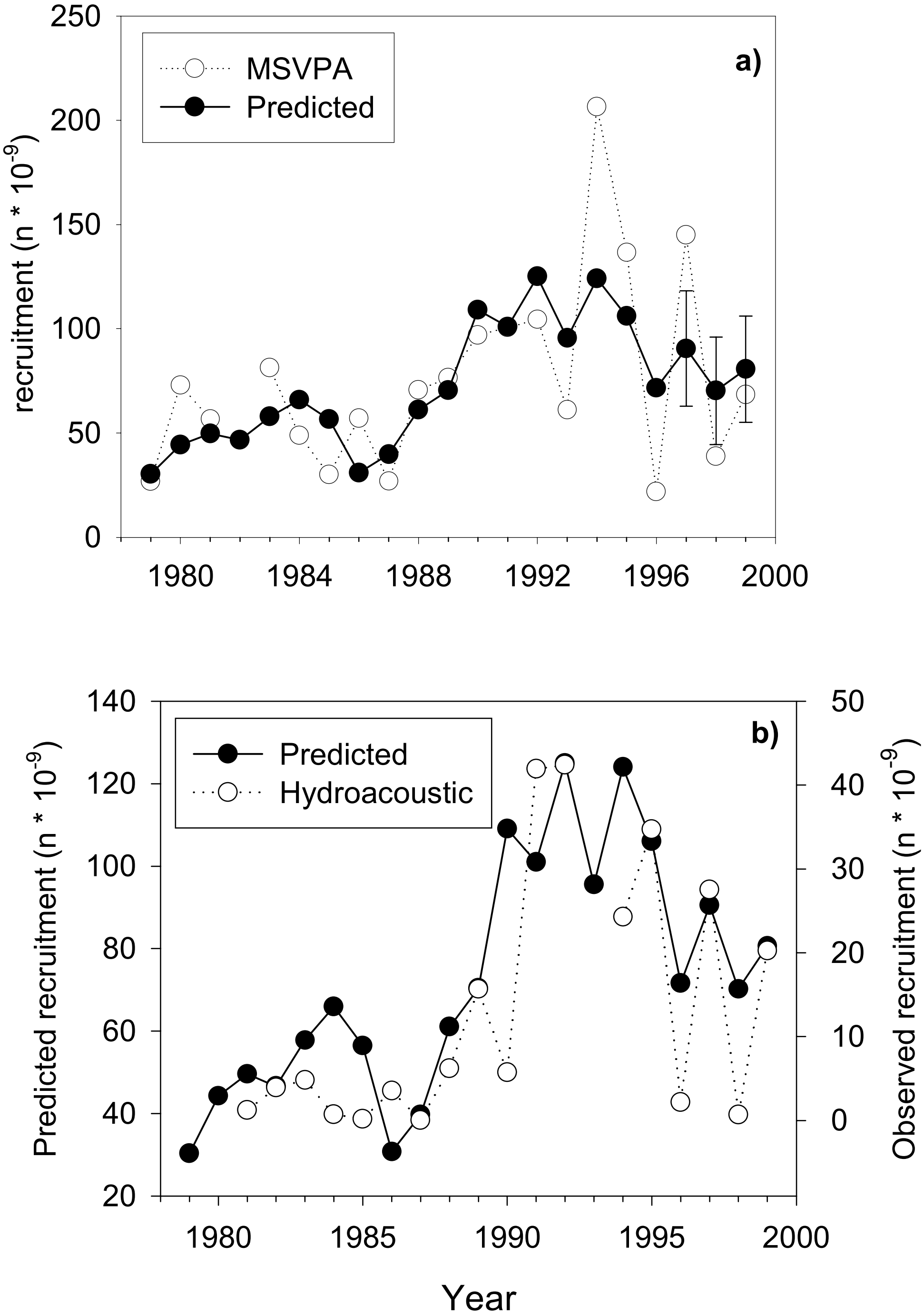


Fig. 6.1.43. Sprat recruitment at age 0 in Sub-divisions 25, 26 and 28 combined predicted by multiple linear regression models established for separate Sub-divisions and observed recruitment from MSVPA (a) and from autumn hydroacoustic surveys (b).

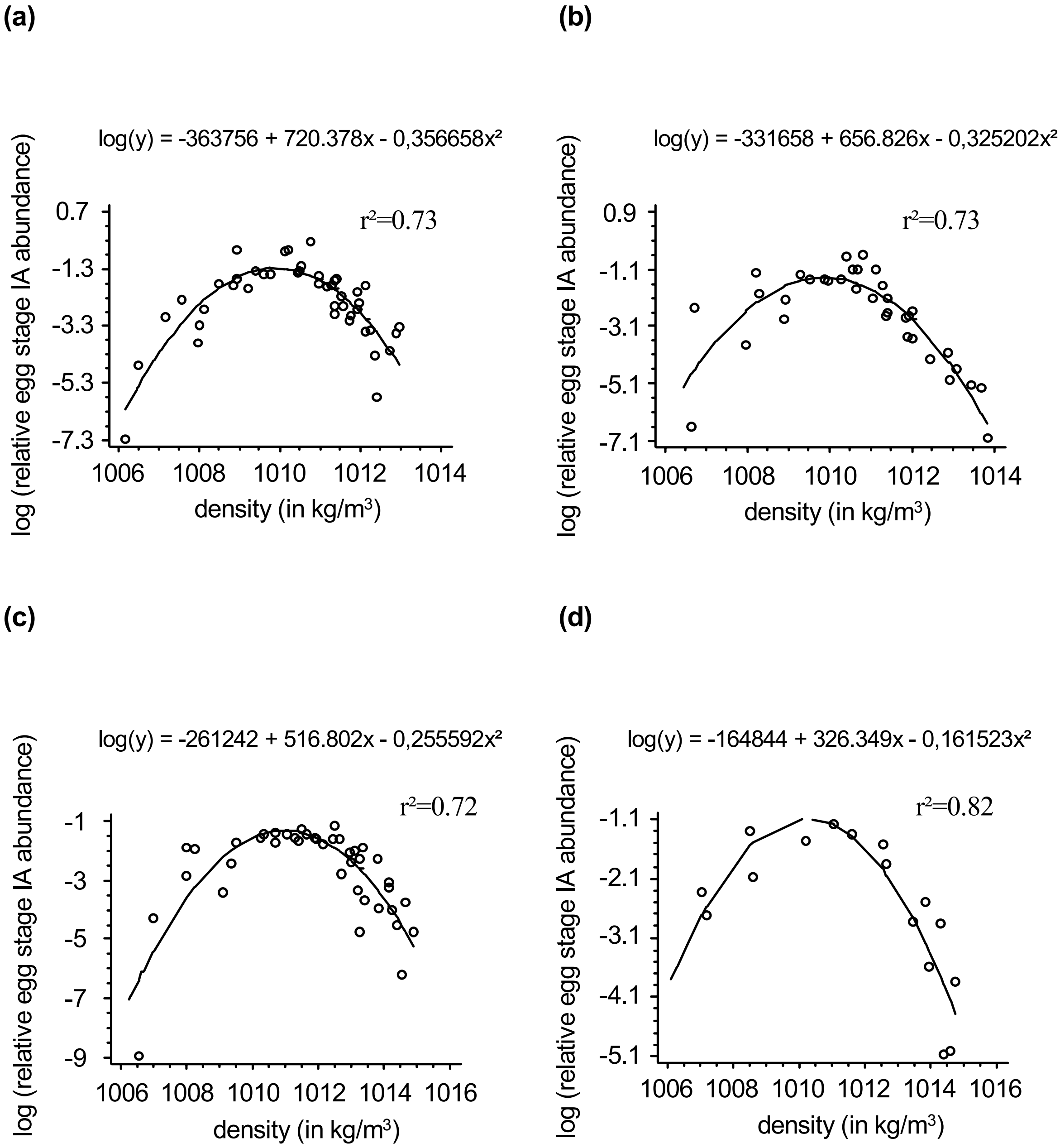


Fig. 6.1.44. Vertical distribution of cod eggs in Subdivision 25: Logarithmic relative abundance of egg stage IA in relation to the ambient density in stagnation periods during spring/early summer (a) and summer spawning (b) as well as inflow periods during spring/early summer (c) and summer spawning (d) together with fitted parabolic functions.

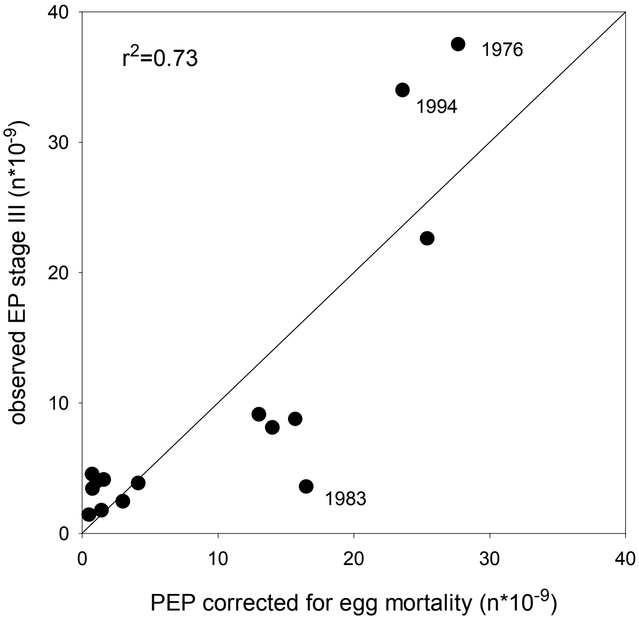


Figure 6.1.45. Linear regression of daily production of cod egg stage III (EP) on potential egg production (PEP) corrected for oxygen related egg survival.

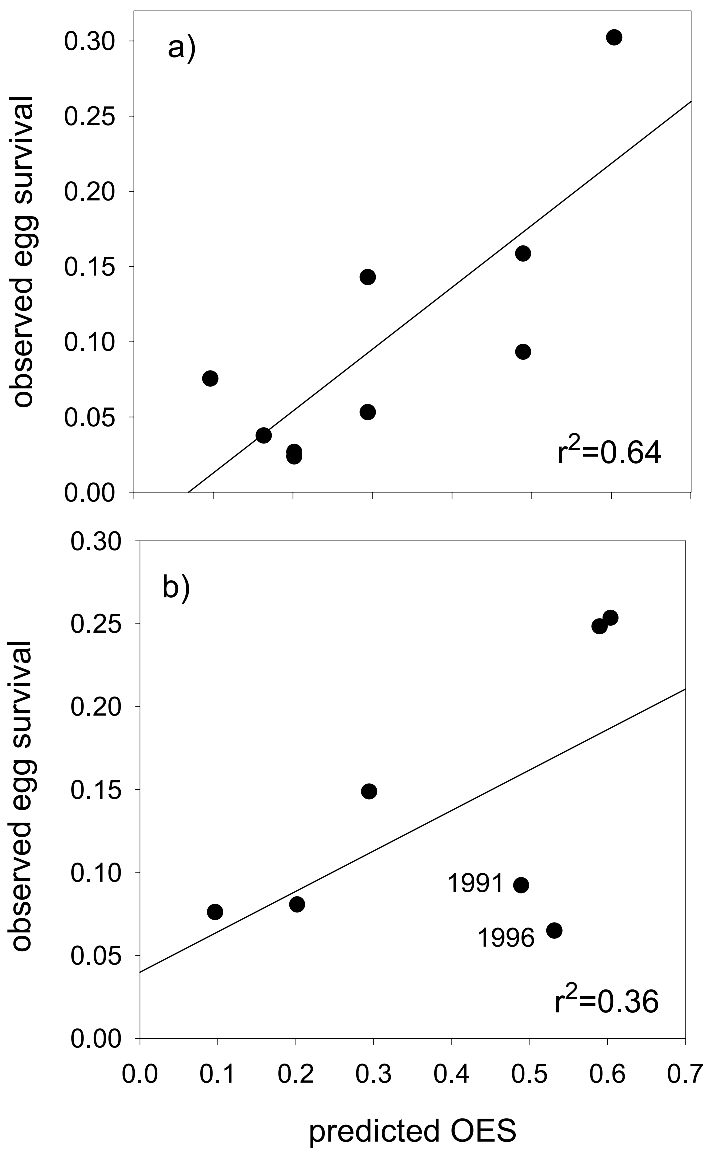


Fig. 6.1.46. Observed egg survival (proportion surviving to stage III) from following cohort development (a) and from seasonal stage specific egg production curves (b) and predicted oxygen related egg survival (OES).

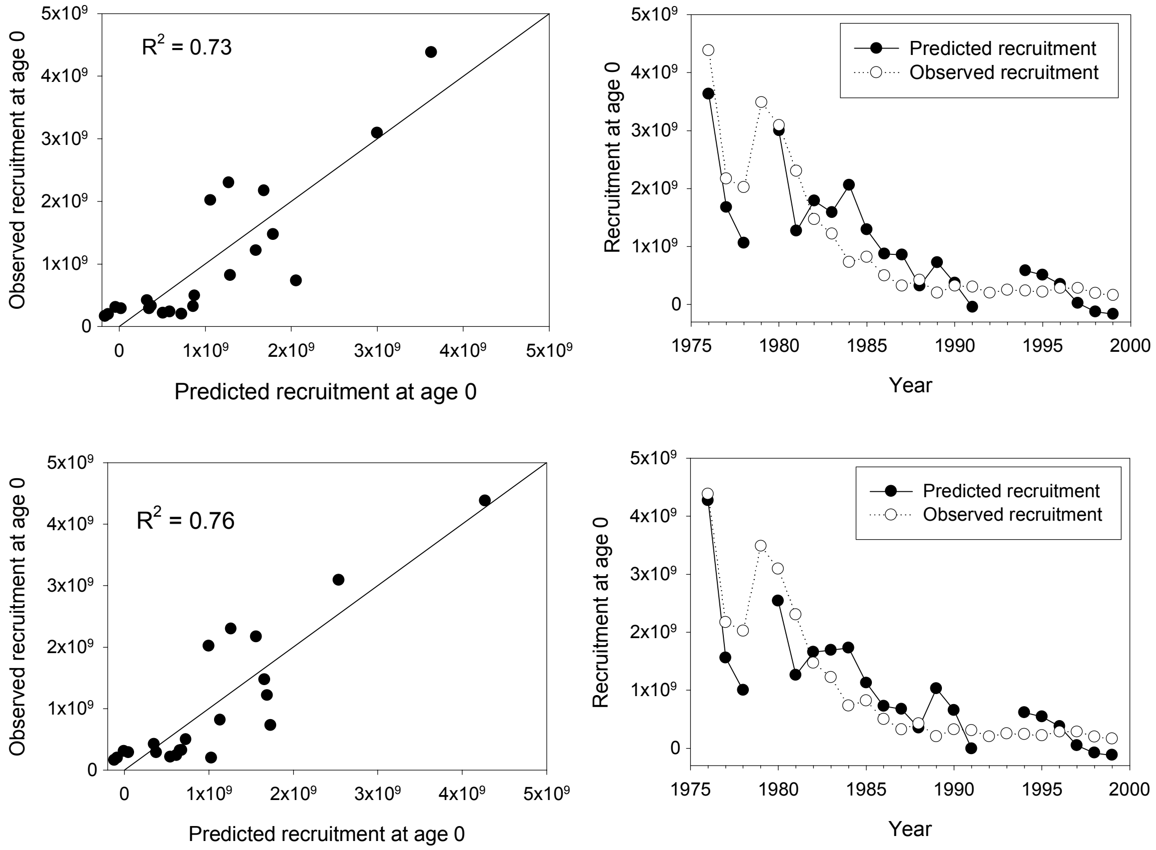


Fig. 6.1.47. Observed vs. predicted recruitment at age 0 based on multiple linear regression model incorporating potential egg production times oxygen related egg survival (as sum over products for Sub-divisions) and prey availability (product of turbulent velocity and *Pseudocalanus* nauplii (upper panel) and total nauplii abundance (lower leve)) as variables.

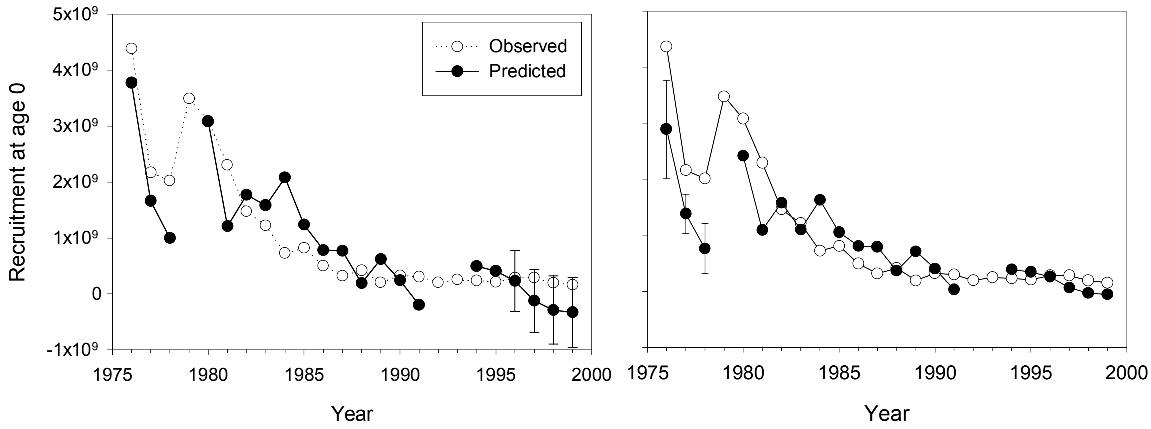


Fig. 6.1.48 Observed and predicted recruitment at age 0 based on multiple linear regression model incorporating potential egg production times oxygen related egg survival (as sum over products for Sub-divisions) and prey availability (product of turbulent velocity and *Pseudocalanus* nauplii) as variables, with model fitted to data covering 1976-1995 (left panel) and 1980-1999 (right panel) with remaining years predicted, error bars correspond to the 95% confidence limits of the predicted means.

Fig. 6.1.49. Observed vs. predicted recruitment at age 0 based on multiple linear regression models for each Sub-division incorporating potential egg production times oxygen related egg survival and prey availability (product of turbulent velocity and *Pseudocalanus* nauplii) as variables, and subsequently integrated over areas.

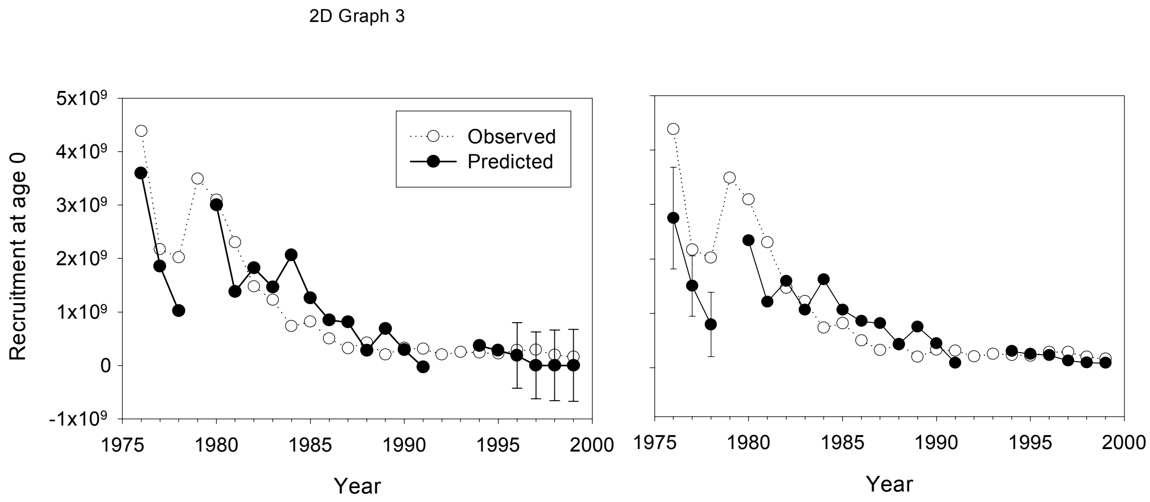


Fig. 6.1.50 Observed and predicted recruitment at age 0 based on multiple linear regression models for each Sub.division incorporating potential egg production times oxygen related egg survival and prey availability (product of turbulent velocity and *Pseudocalanus* nauplii) as variables, integrated subsequently over areas, with model fitted to data covering 1976-1995 (left panel) and 1980-1999 (right panel) with remaining years predicted, error bars correspond to the 95% confidence limits of the predicted means.

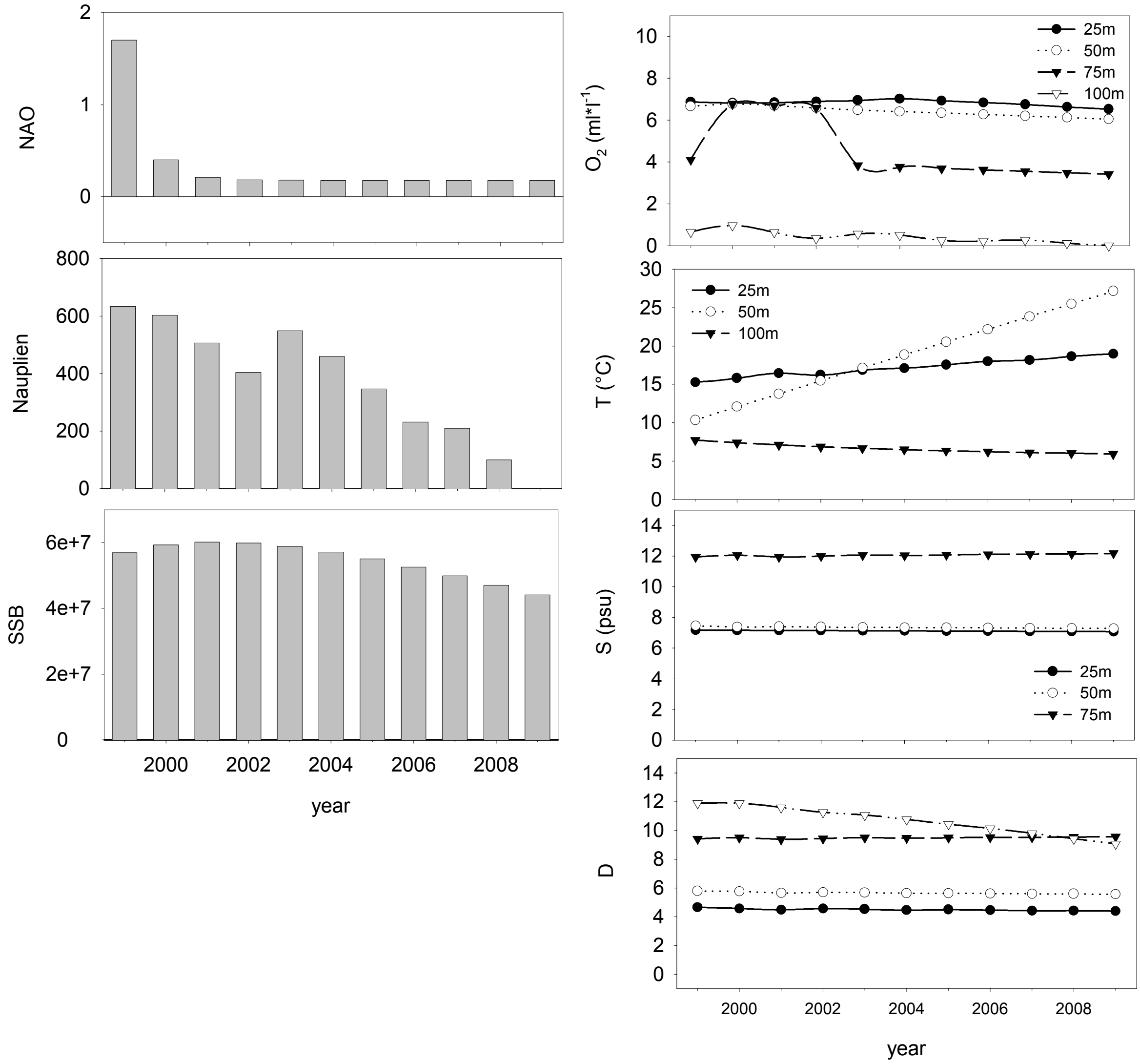


Fig. 6.1.51. ARIMA model prediction output for SSB and environmental variables for 1999-2009 identified to significantly influence cod recruitment success in Subdivision 25.

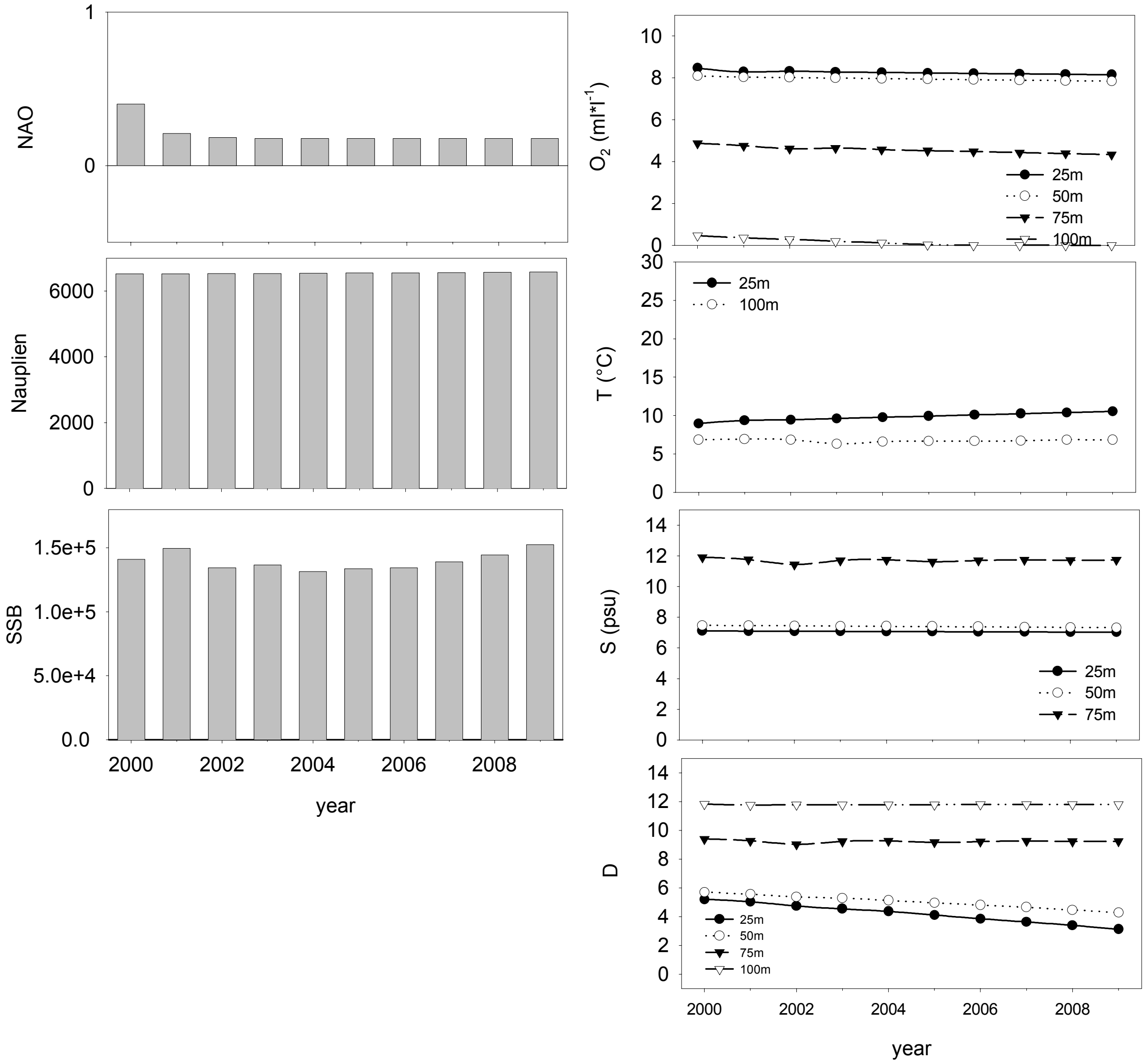


Fig. 6.1.52. ARIMA model prediction output for SSB and environmental variables for 2000-2009 identified to significantly influence sprat recruitment success in Subdivision 26.

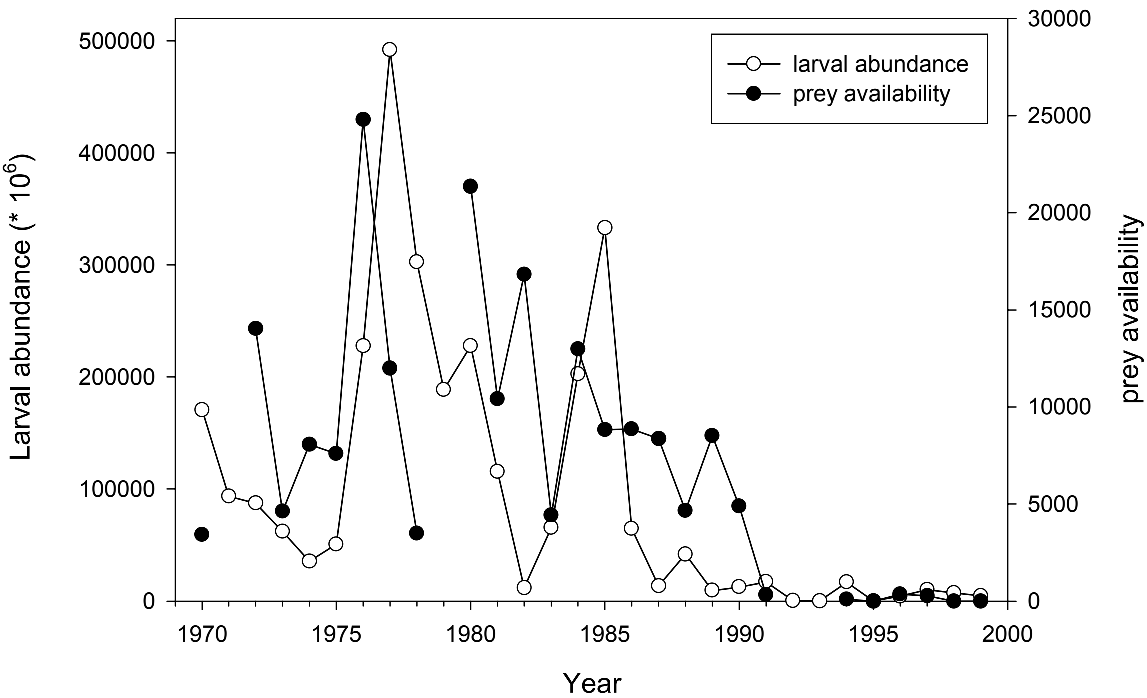


Fig. 6.2.1, Cod larval abundance in the Central Baltic and prey availability index (product of *Pseudocalanus elongatus* nauplii abundance [n*m^{-3}] * turbulent velocity).

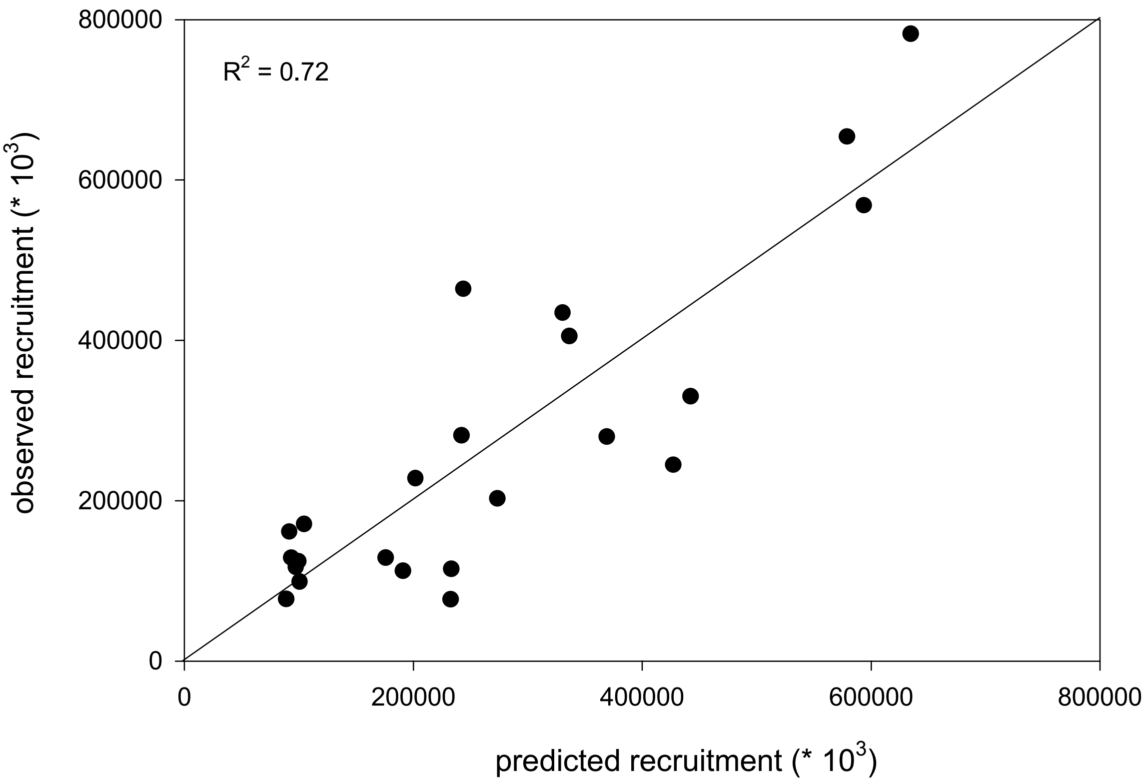


Fig. 6.2.2. Observed vs. predicted cod recruitment at age 2 as output of the XSA (ICES 2002) and predicted from the statistical model including larval abundance and prey availability as variables covering the period 1970-1999.

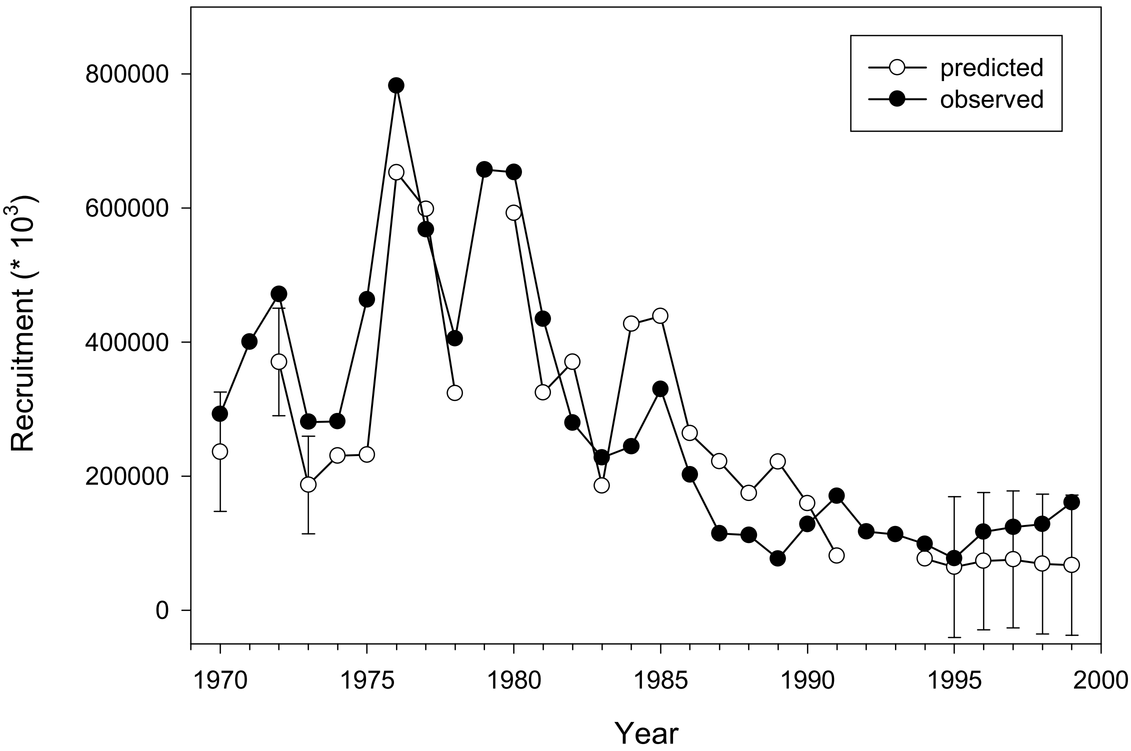
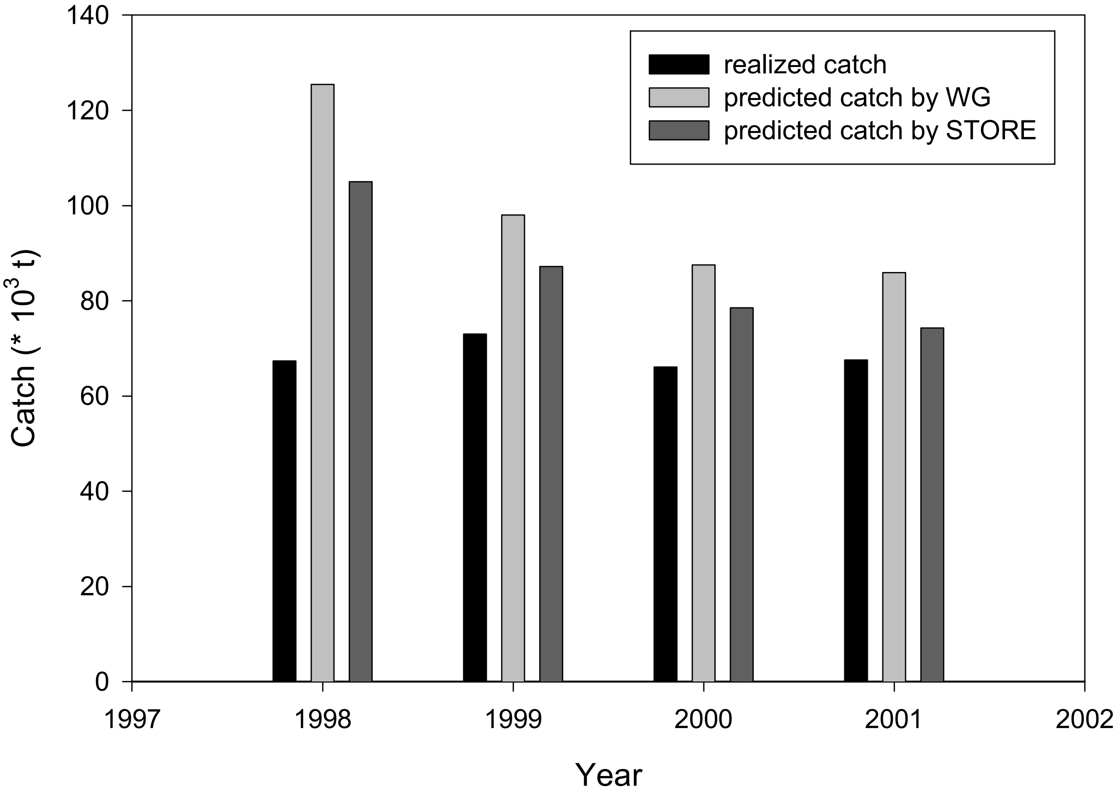


Fig. 6.2.3. Cod recruitment at age 2 (year of origin) as output of XSA (ICES, 2002) (observed) and predicted from the statistical model including larval abundance and prey availability as variables; the model was fitted to data covering the period 1974-1994, while 1970, 1972 and 1973 as well as 1995-1995 were predicted, with 95% confidence limits of the predicted means).



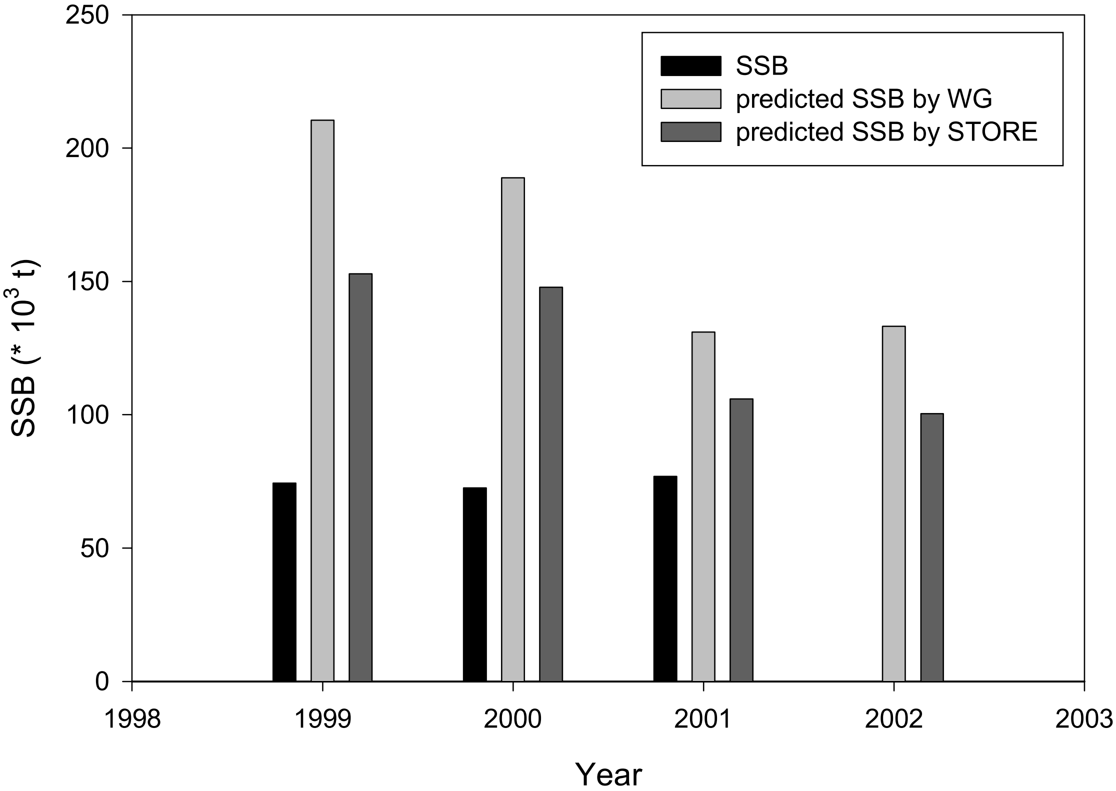


Fig. 6.2.4. Catch and SSB of cod from short-term predictions conducted in 1997-2000 by the Baltic Fisheries Assessment Working Group (WG) for 1998-2001 and 1999-2002, respectively in comparison to corresponding prediction output utilizing the statistical larval abundance/prey availability – recruitment relationship (STORE) and output of the last assessment (ICES, 2002), being the best available estimate).

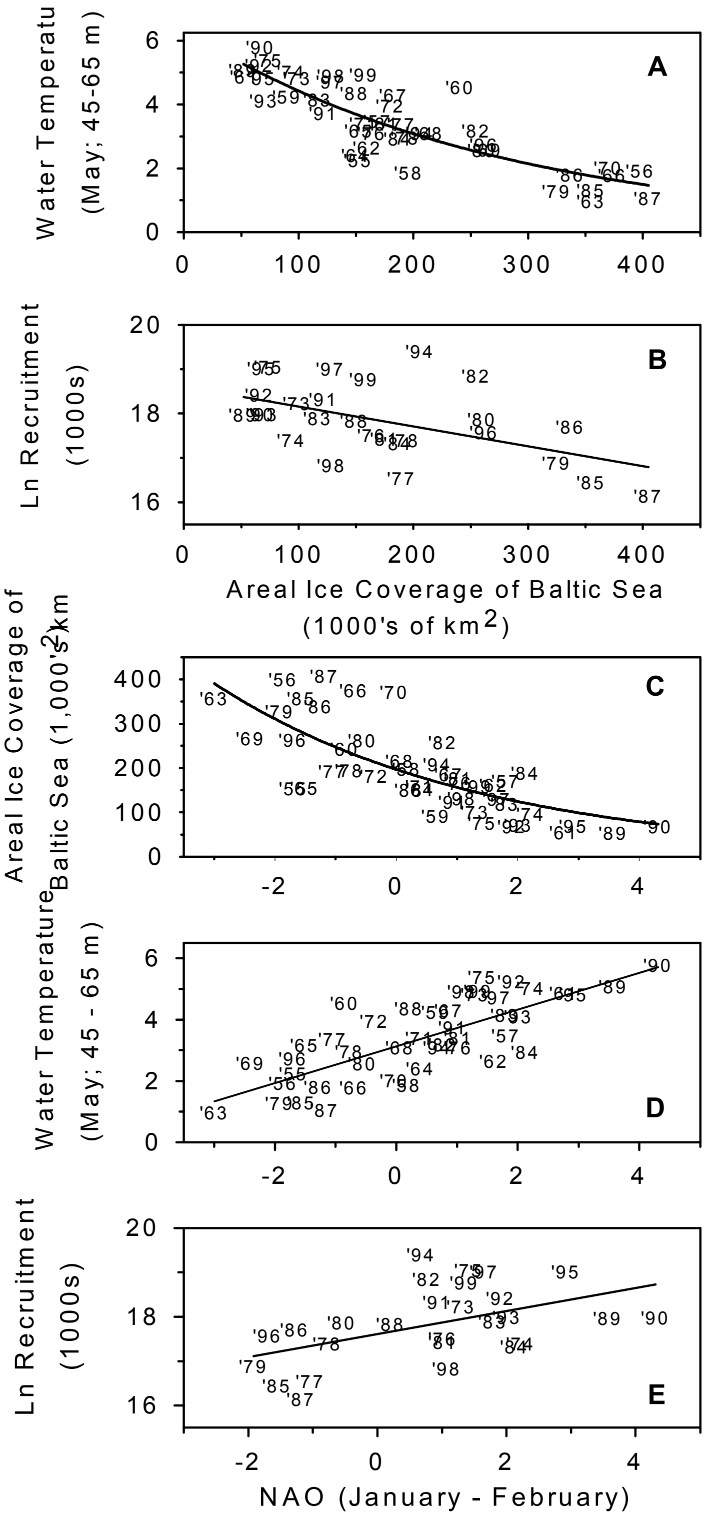


Fig. 6.2.5. Inter-relationships between May water temperature at 45-65 m in the Bornholm Basin, maximal areal extent of ice coverage in the Baltic Sea, the North Atlantic Oscillation index for January-February and $\log_e$ sprat recruitment. In panels B and E, environmental data were collected in the year of birth of sprat; symbols denote sprat birth years. Relationships among environmental variables (1955-1999) and between environmental variables and recruitment (1973-1999): **A**) $T = 6.4e^{-0.0036Ice}$, $R^2_{adj.} = 72\%$, $P < 0.0001$, $SE_{est} = 0.684$, DW = 1.53; **B**) $\ln R = 18.61 - 0.0045*ICE$, $R^2_{adj.} = 24\%$, $P = 0.0054$, $SE_{est} = 0.740$, DW = 2.33; **C**) $Ice = 196e^{-0.23NAOJF}$, $R^2_{adj.} = 56\%$, $P < 0.0001$, $SE_{est} = 66.6$, DW = 2.04; **D**) $T = 3.1 + 0.6NAOJF$, $R^2_{adj.} = 57\%$, $P < 0.0001$, $SE_{est} = 0.847$, DW = 1.76; **E**) $\ln R = 17.2 + 0.26*NAOJF$, $R^2_{adj.} = 22\%$, $P = 0.0081$, $SE_{est} = 0.751$, DW = 2.35. SE_{est} and DW are respectively the standard errors of the estimate and Durbin – Watson autocorrelation statistics.

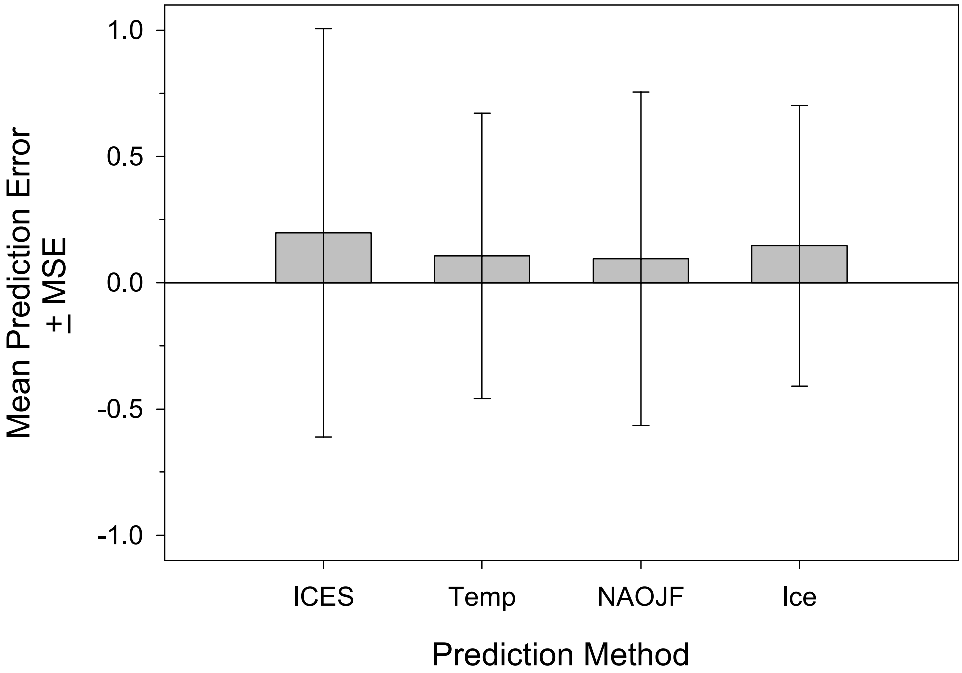


Fig. 6.2.6. Comparison of prediction error (mean deviation of observed from predicted recruitment) and mean square error (error bars) of recruitment predicted using different methods: recruitment estimated as geometric mean of previous 10 years; Temp, NAOJF and ICE: recruitment estimated using environmental regression models. Predictions were generated for each year class 1983 – 1999.

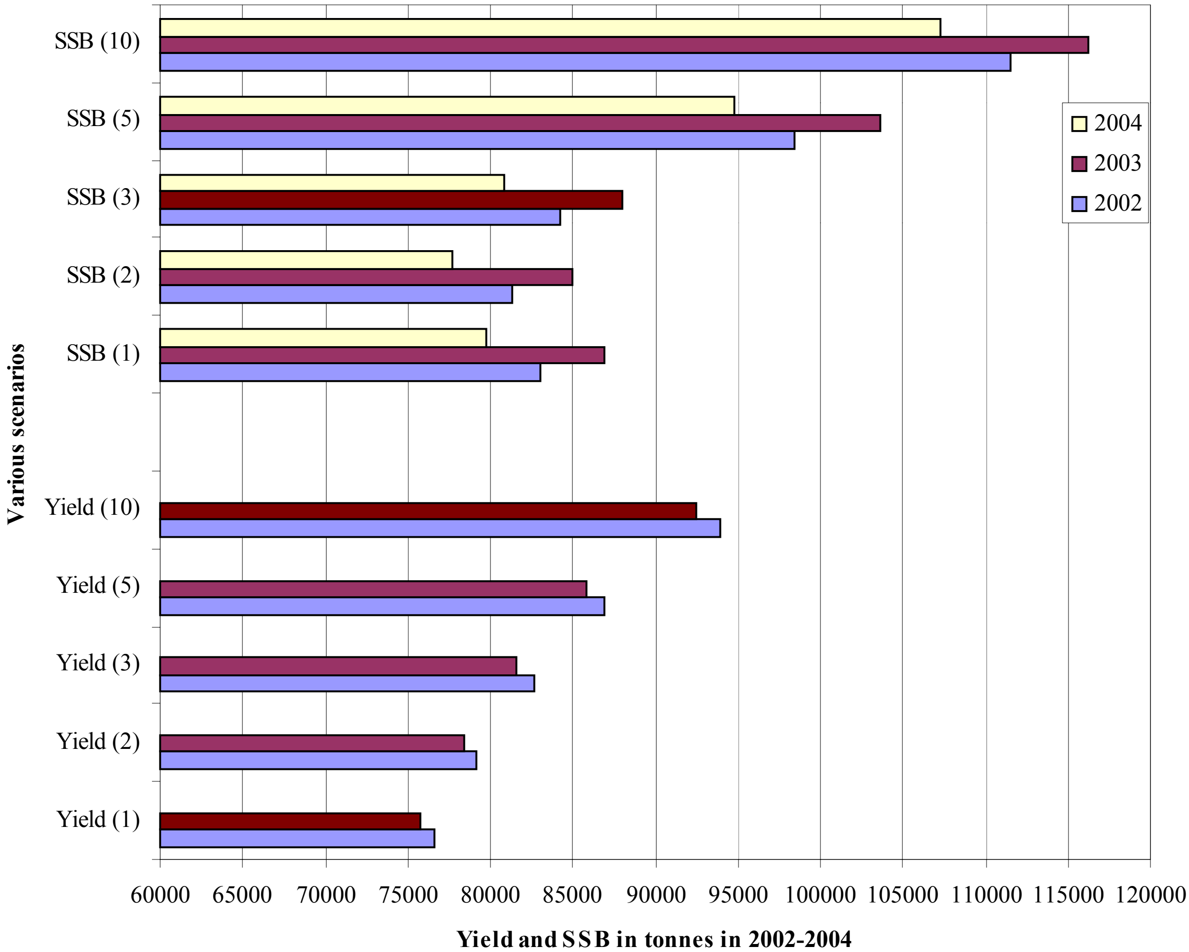


Fig. 6.2.7. Short term prediction of Cod in SD 25-32 with status quo fisheries (The use of mean WECA and WEST data range from one last observation year up to 10 last years' average).

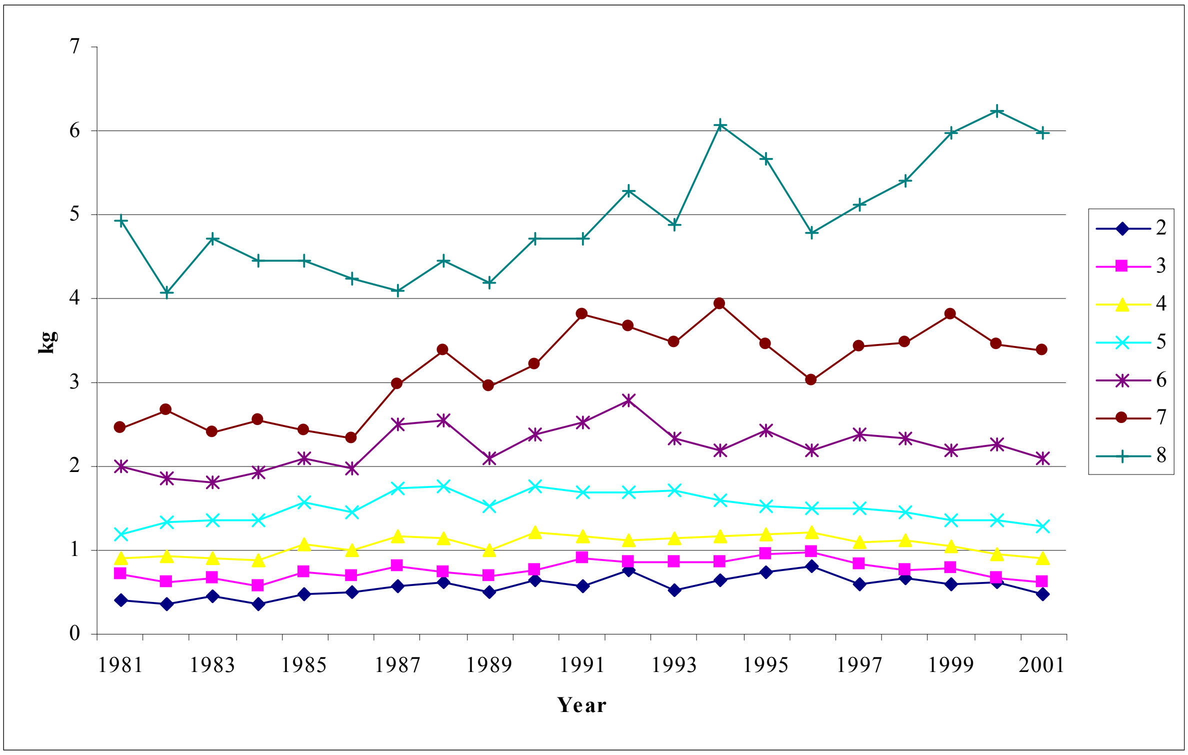


Fig. 6.2.8. Mean weight at age of cod in the catch (kg).

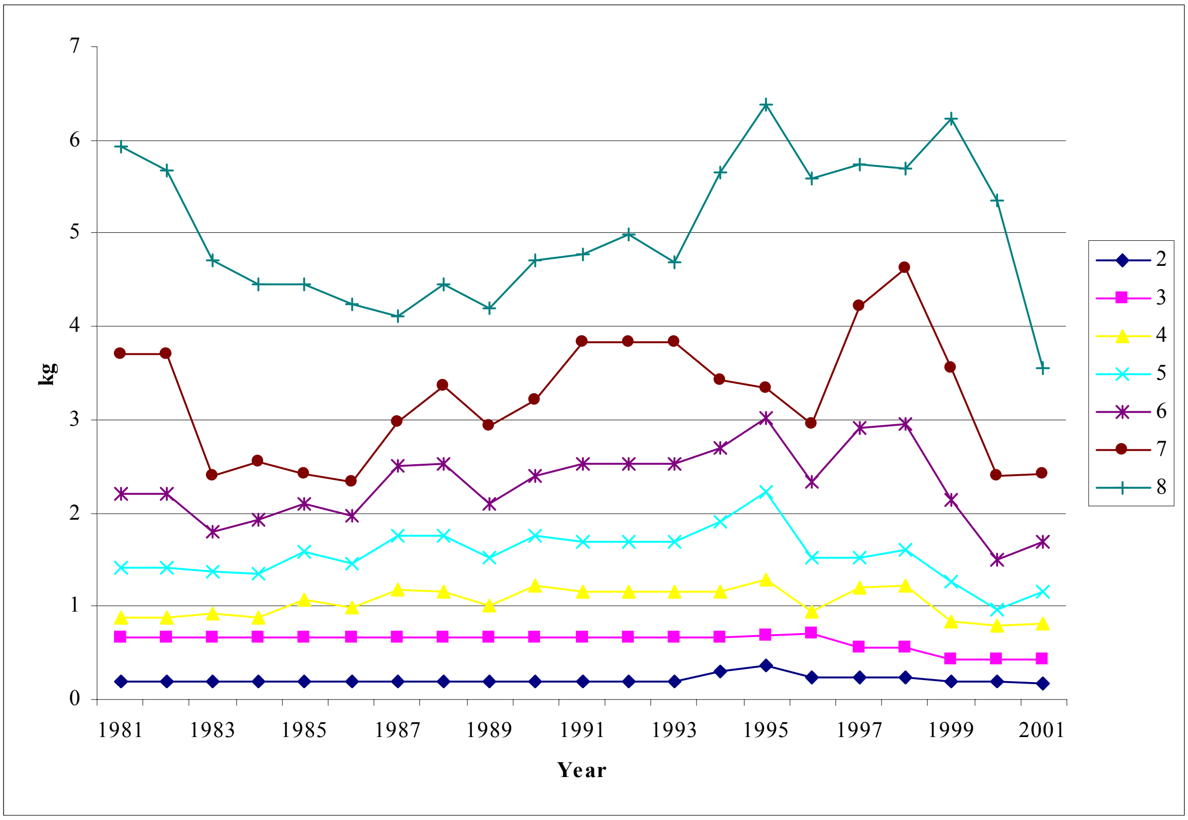
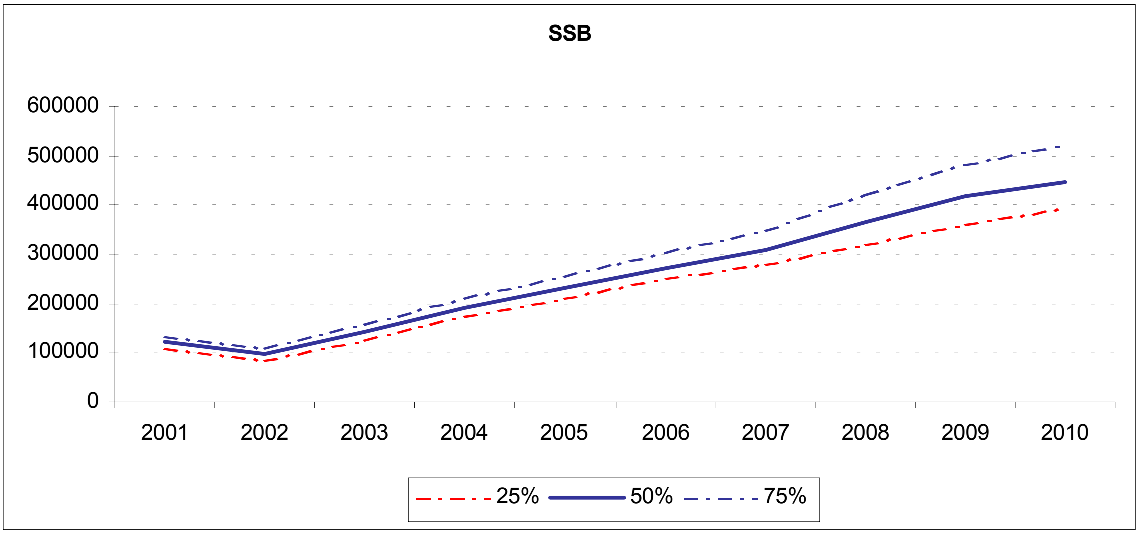
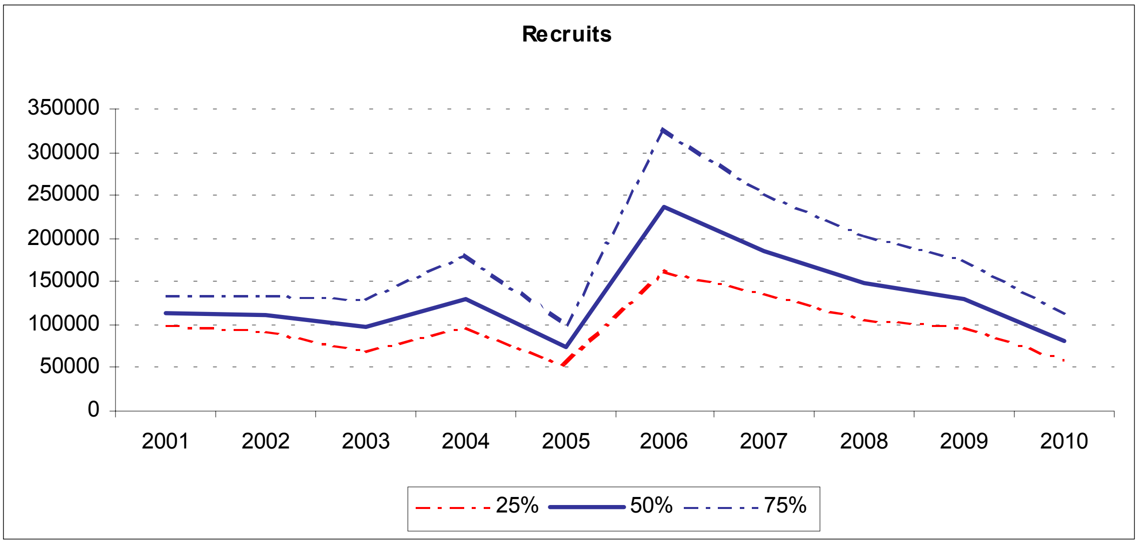


Figure 6.2.9. Mean weight at age of cod in the stock (kg)

B6, F = 0.5 F_{PA} = 0.3, Environment start year : 1993





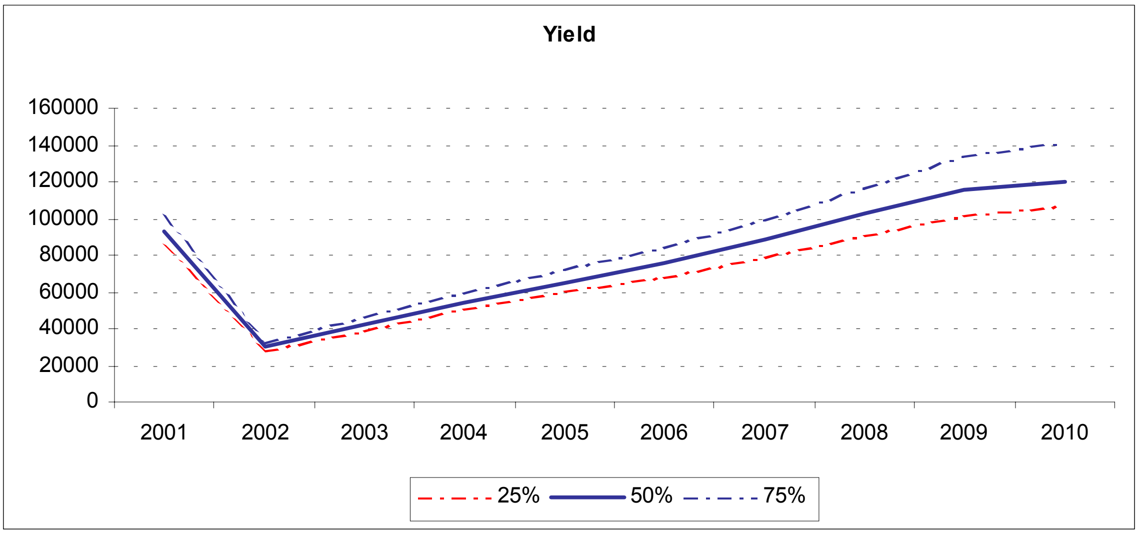
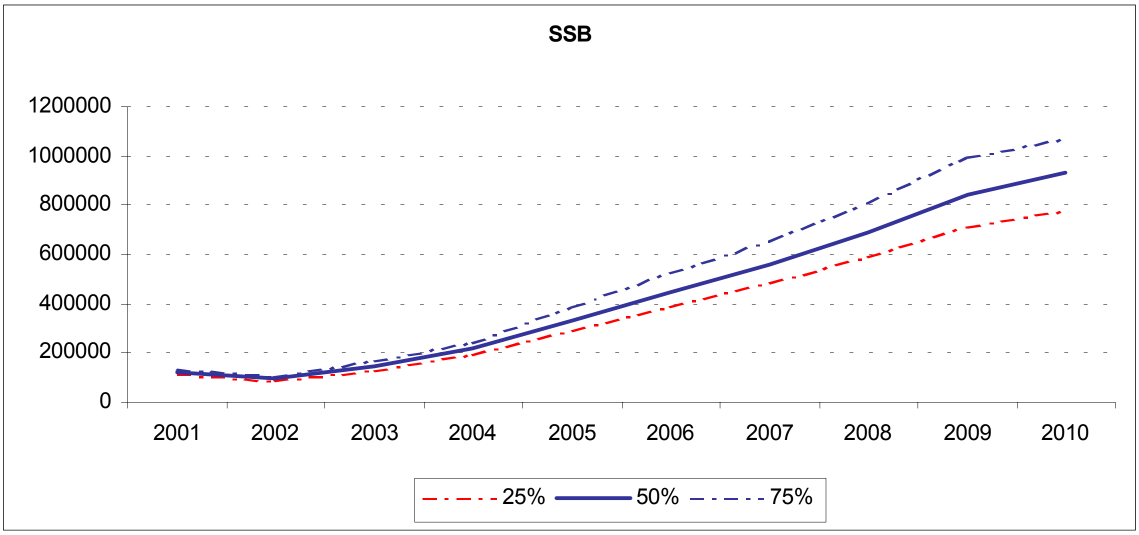
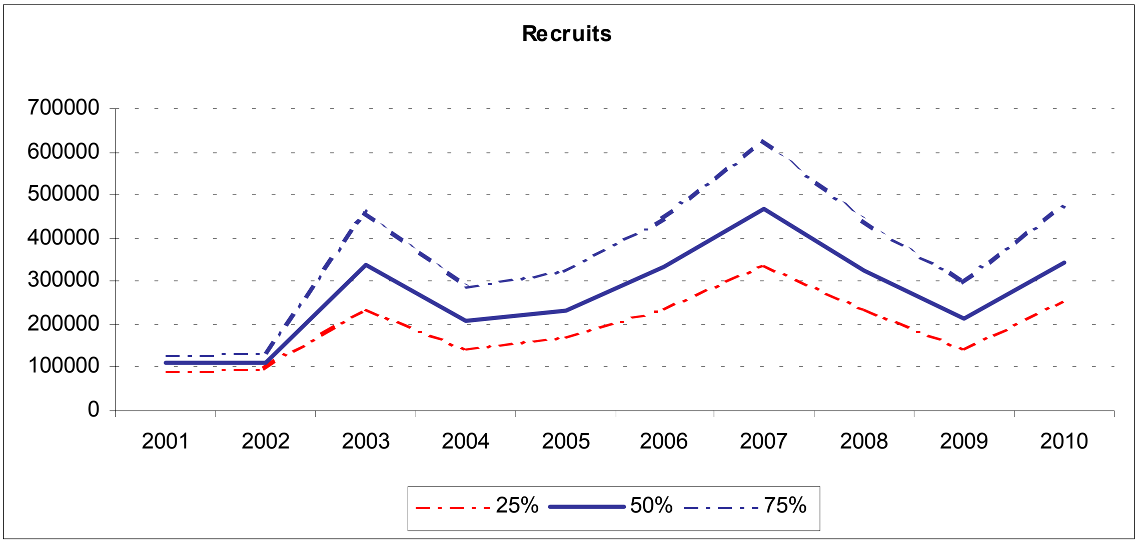


Figure 6.3.1. Medium-term projection results for Baltic cod.

B7, F = 0.5 F_{PA} = 0.3, Environment start year : 1976





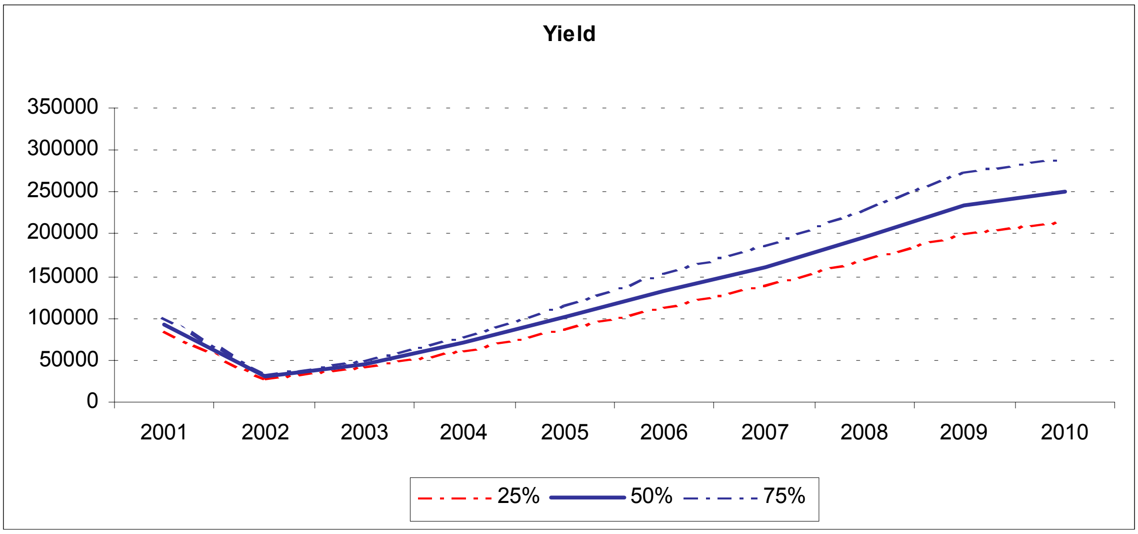
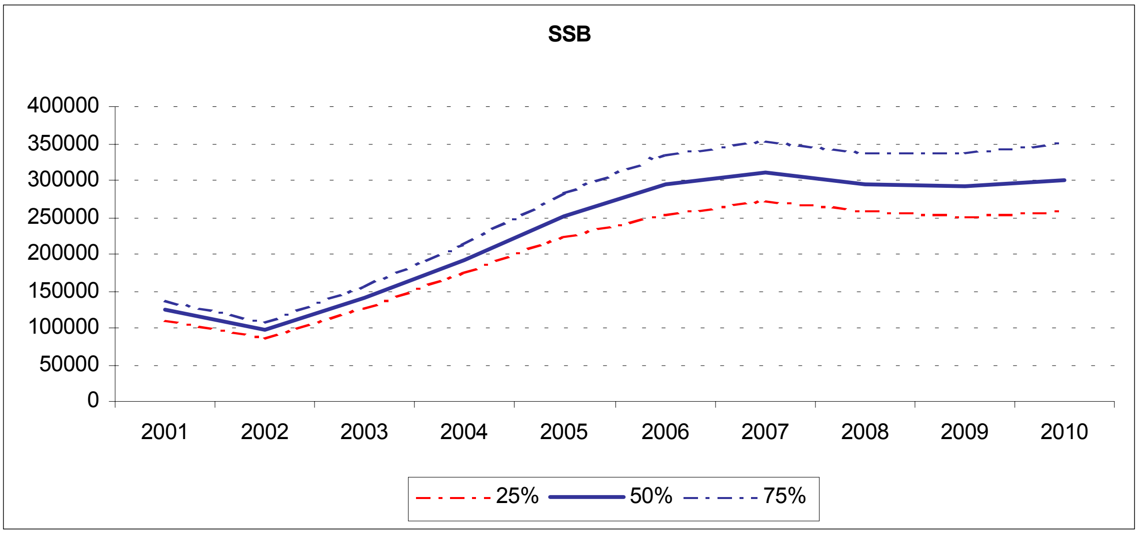
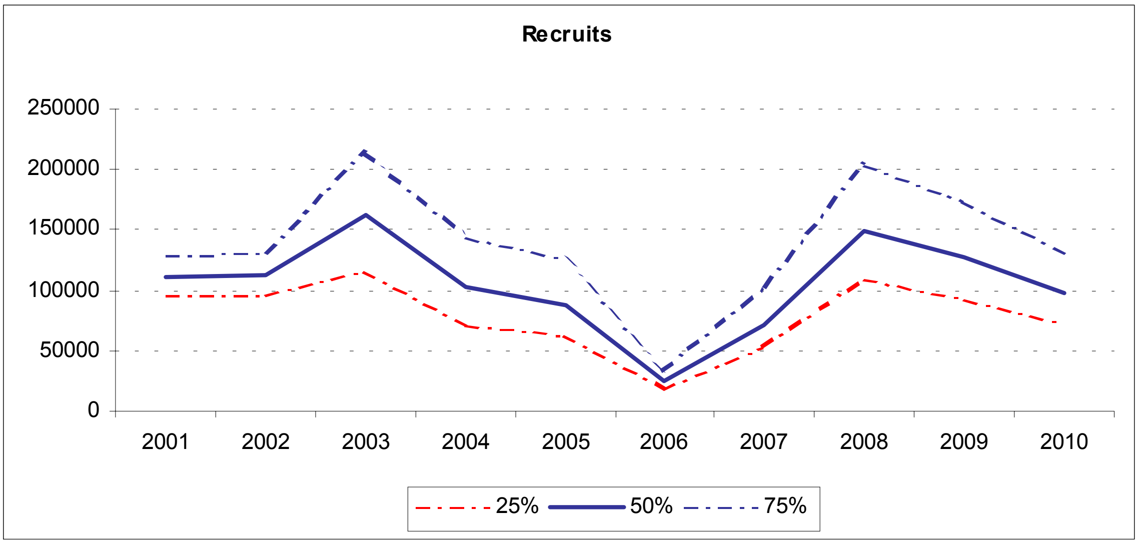


Figure 6.3.2. Medium-term projection results for Baltic cod.

B8, F = 0.5 F_{PA} = 0.3, Environment start year : 1996





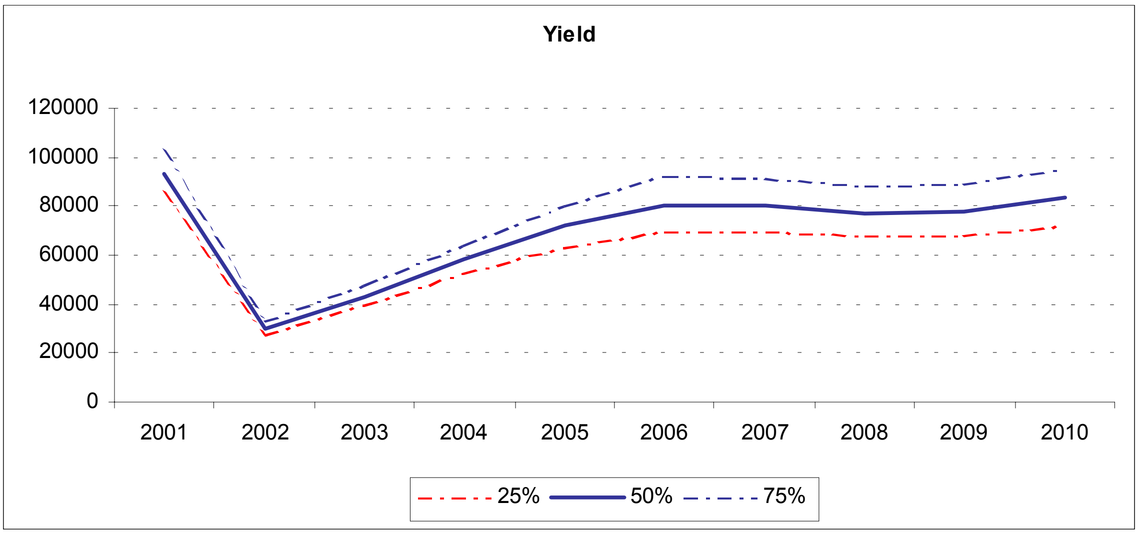
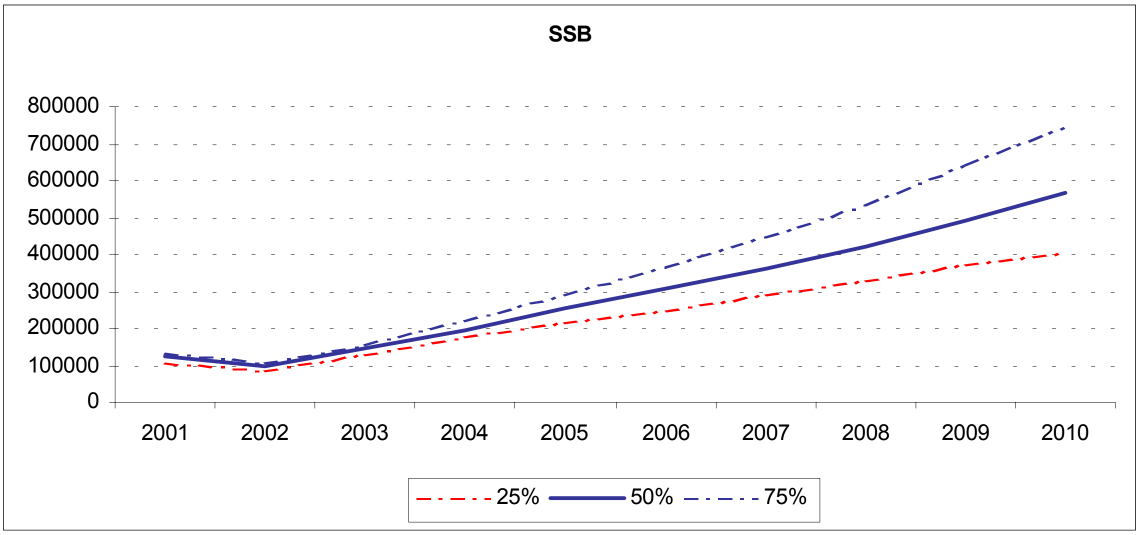
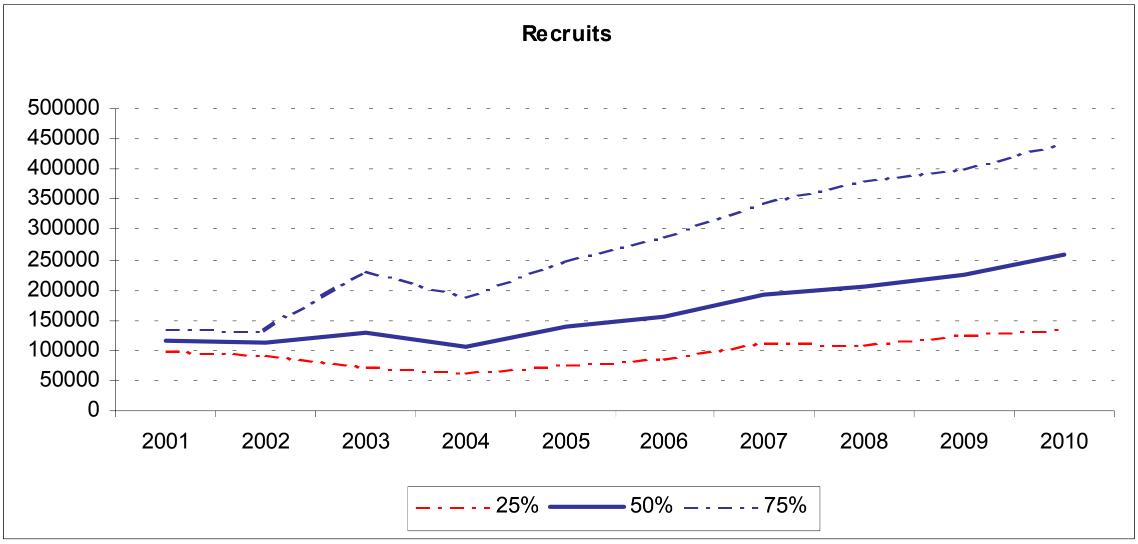


Figure 6.3.3. Medium-term projection results for Baltic cod.

B9, F = 0.5 F_{PA} = 0.3, Environment start year : Random





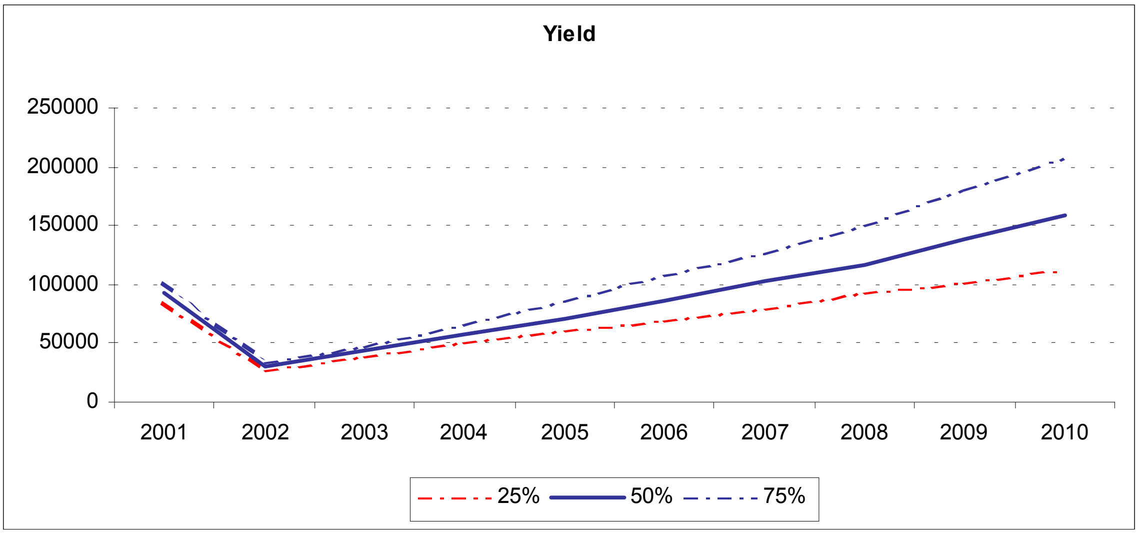
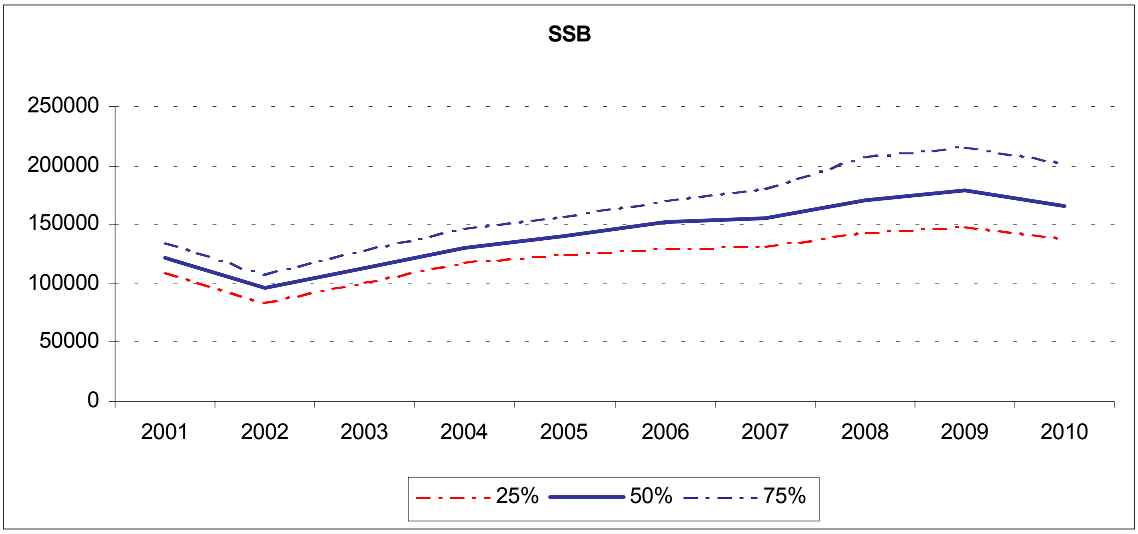
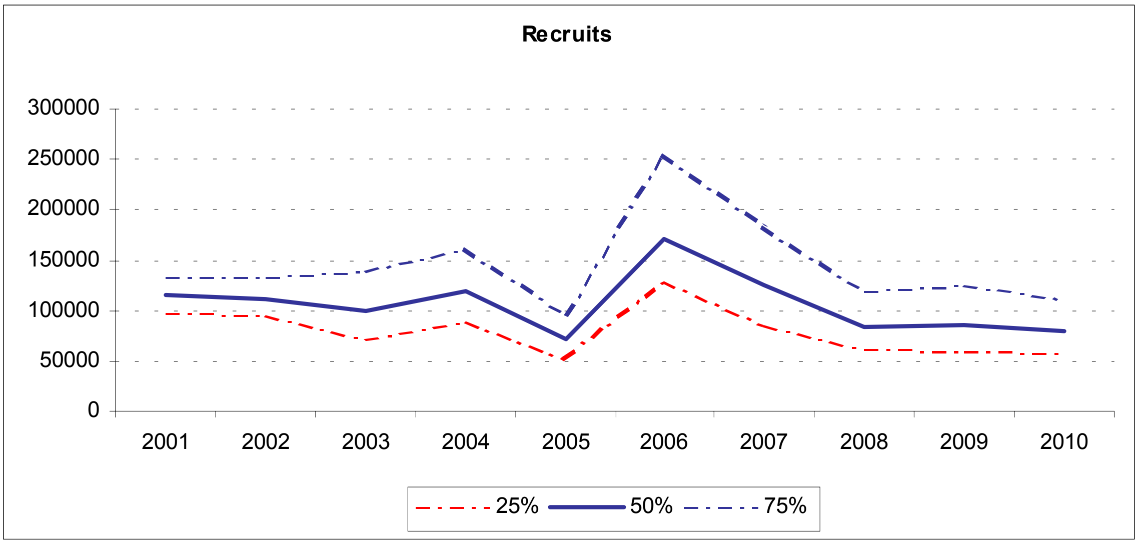


Figure 6.3.4. Medium-term projection results for Baltic cod.

C6, F = F_{PA} = 0.6, Environment start year : 1993





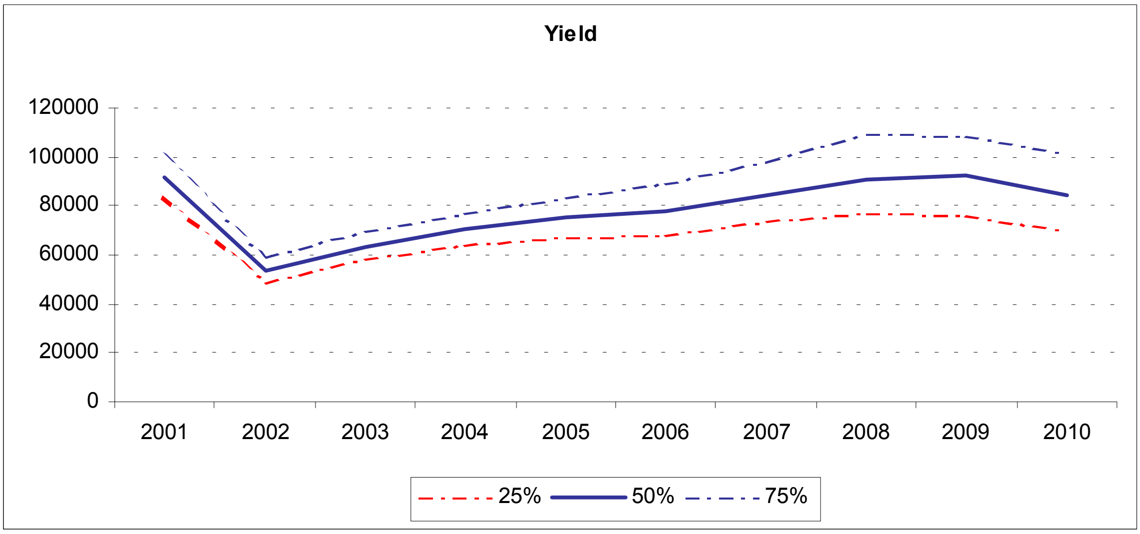
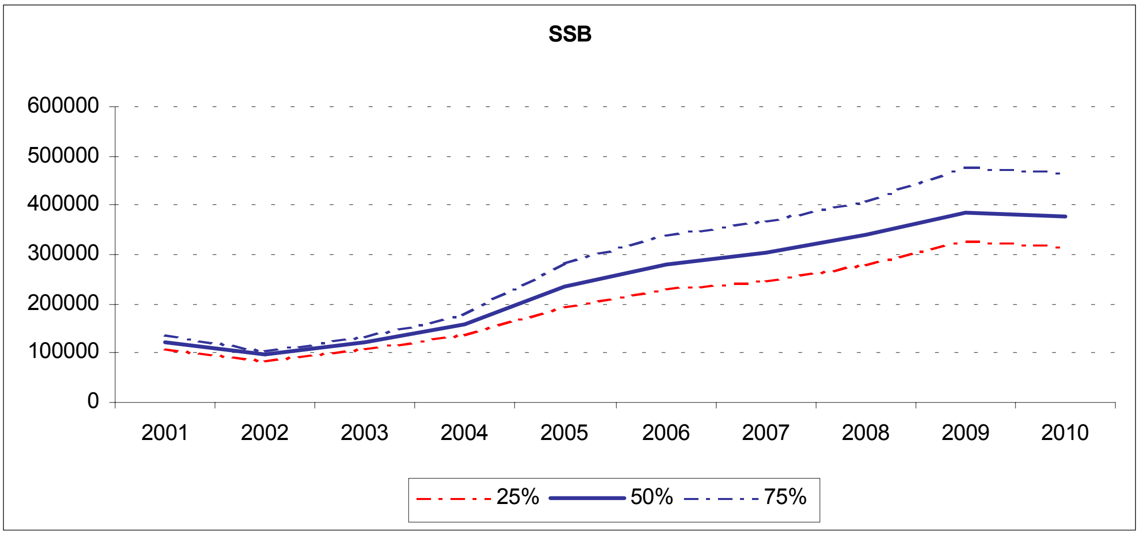
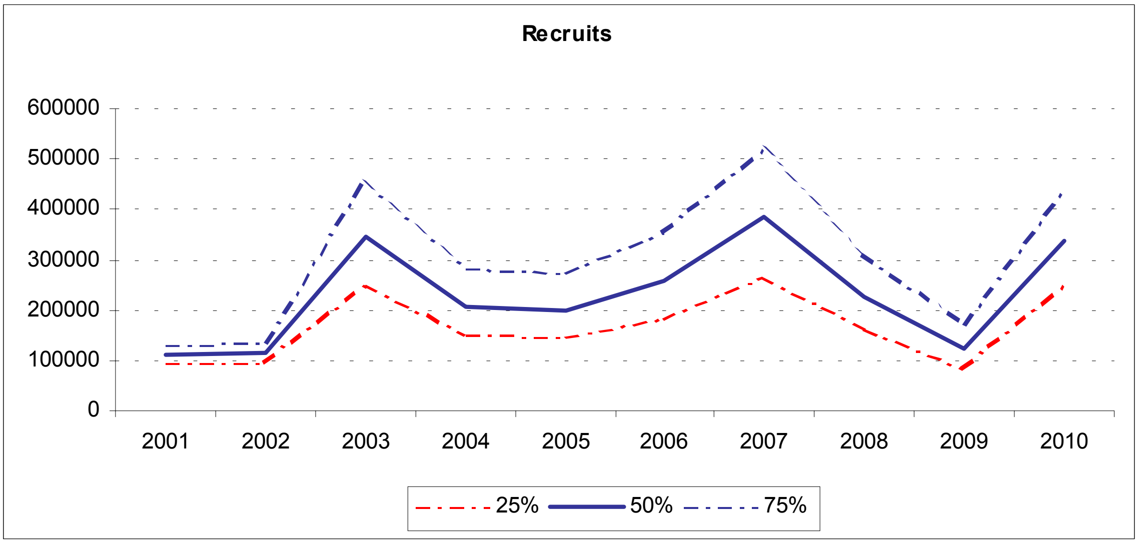


Figure 6.3.5. Medium-term projection results for Baltic cod.

C7, F = F_{PA} = 0.6, Environment start year : 1976





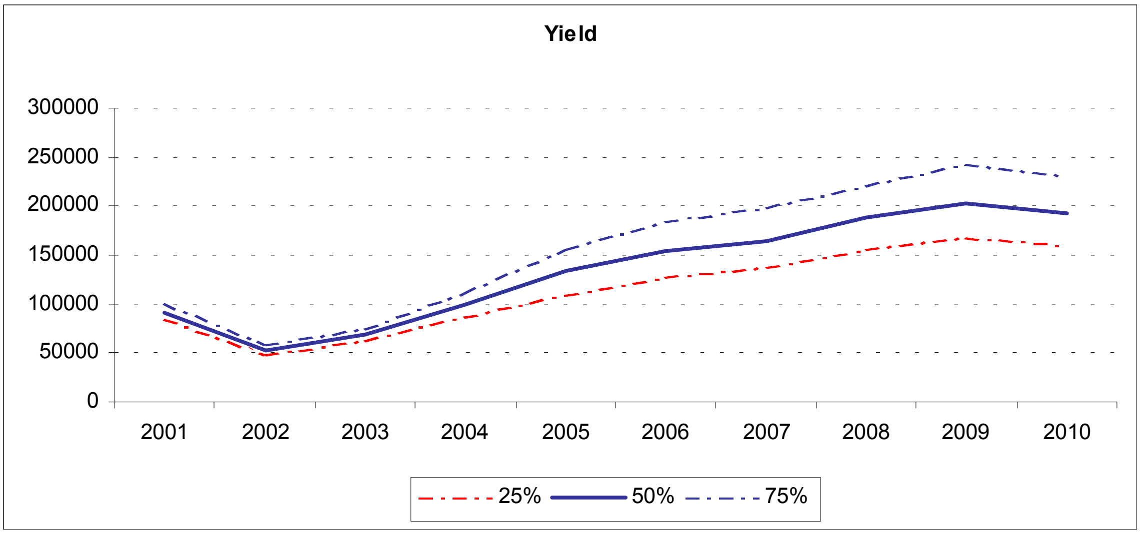
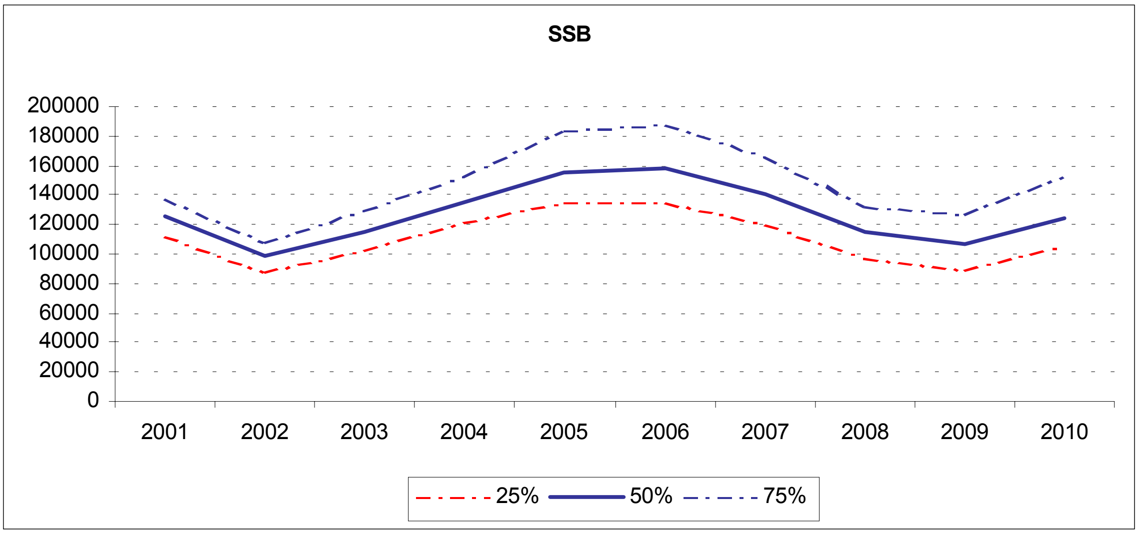
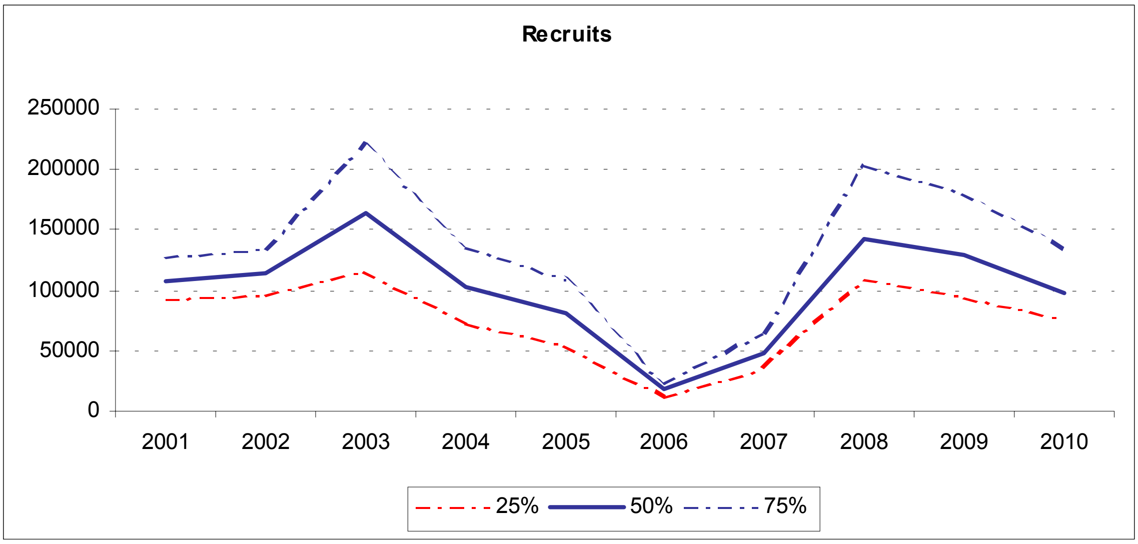


Figure 6.3.6. Medium-term projection results for Baltic cod.

C8, F = F_{PA} = 0.6, Environment start year : 1986





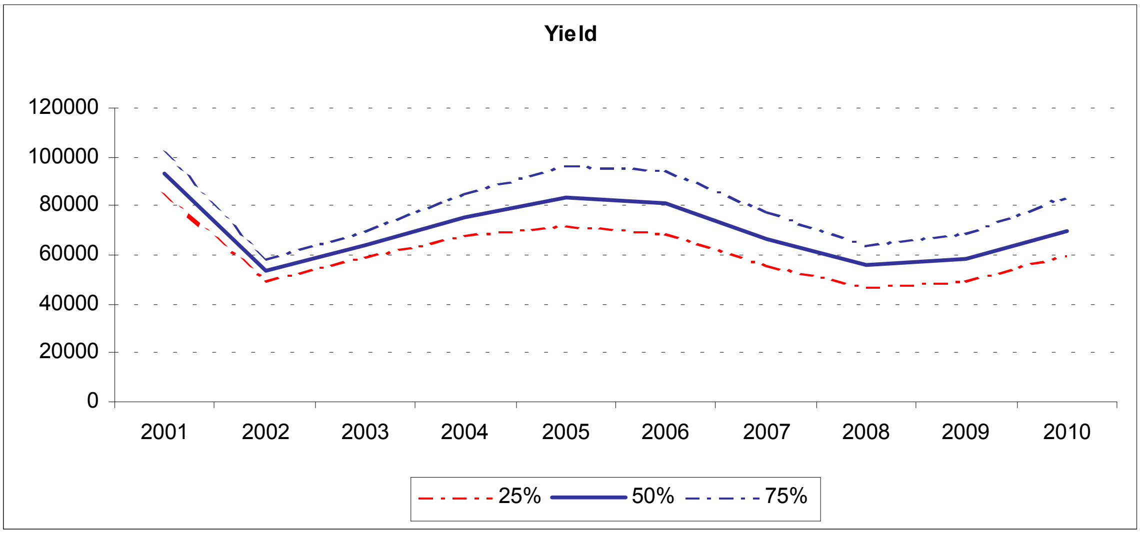
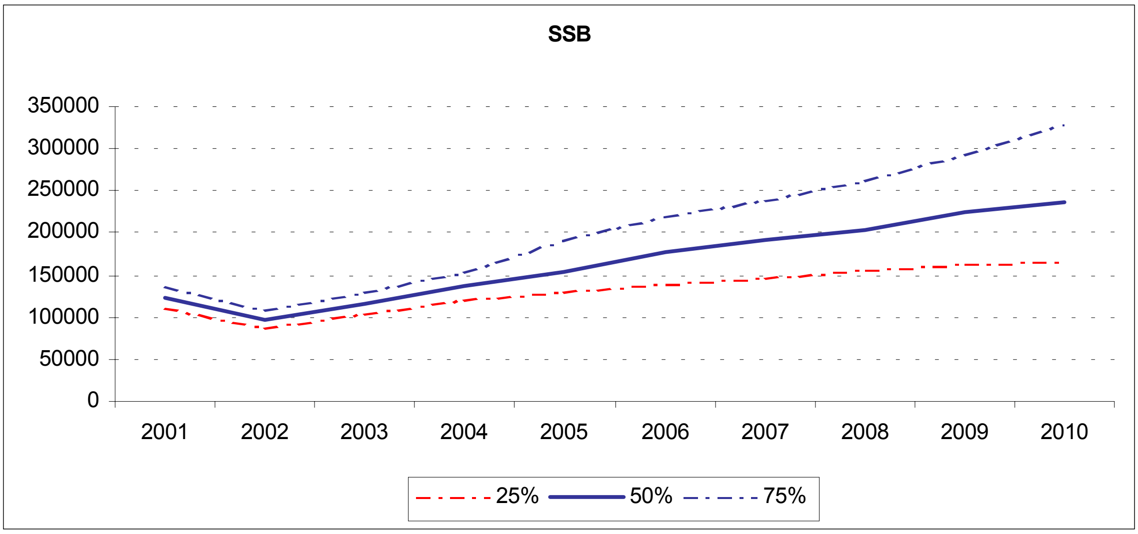
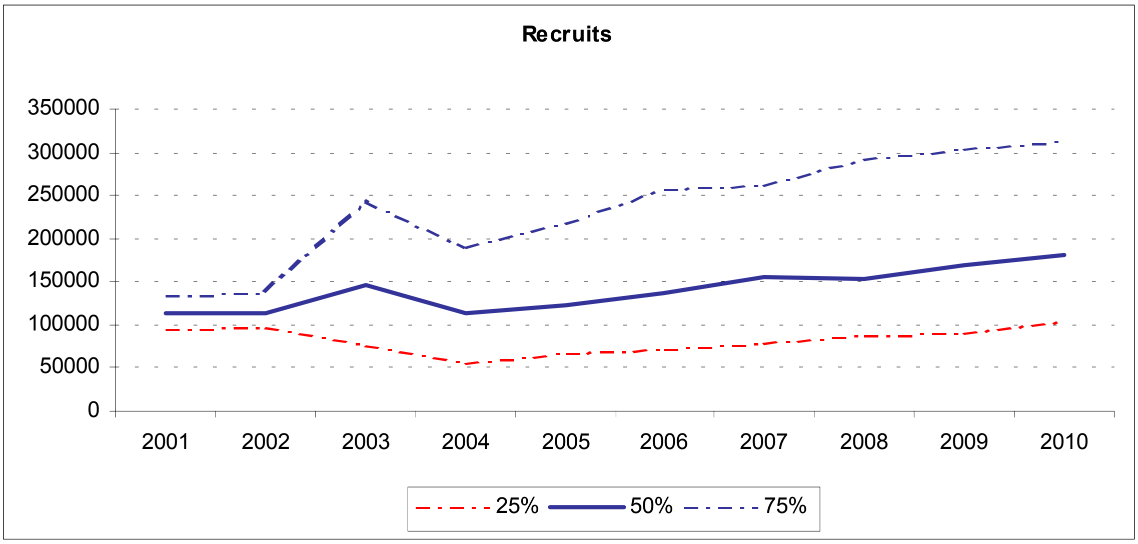


Figure 6.3.7. Medium-term projection results for Baltic cod.

C9, F = F_{PA} = 0.6, Environment start year : Random





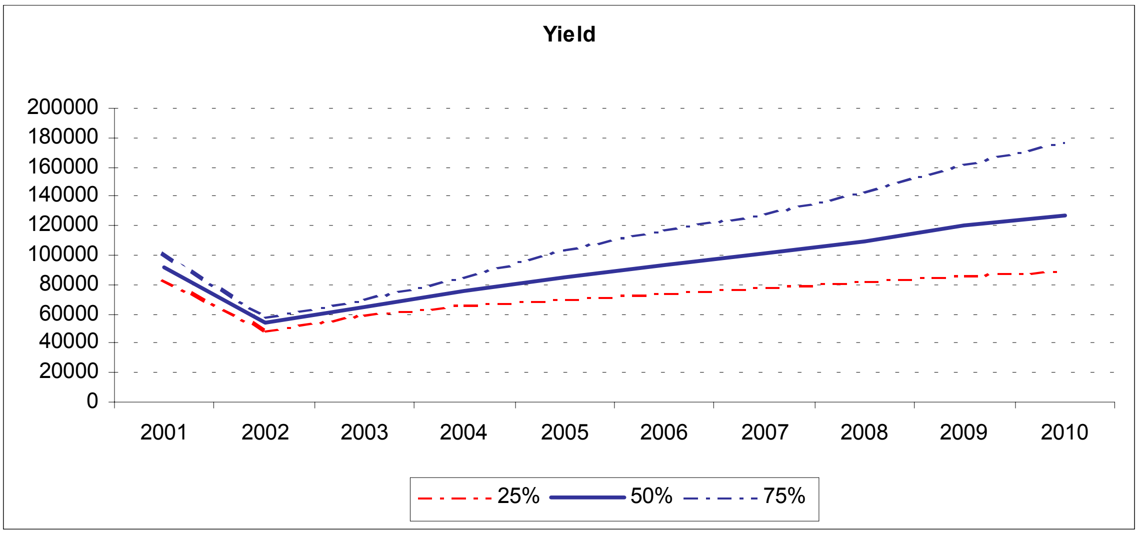
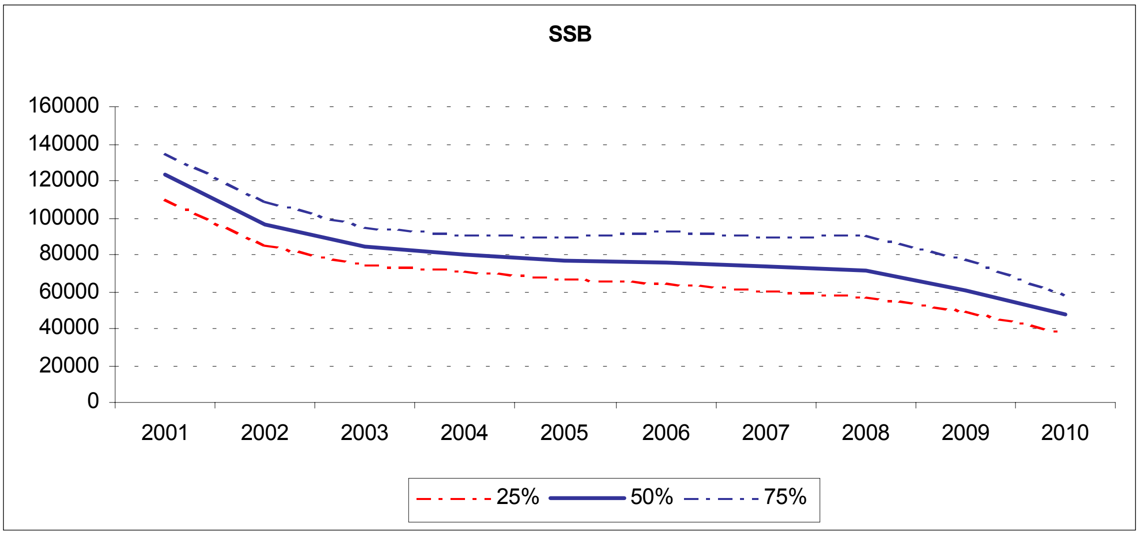
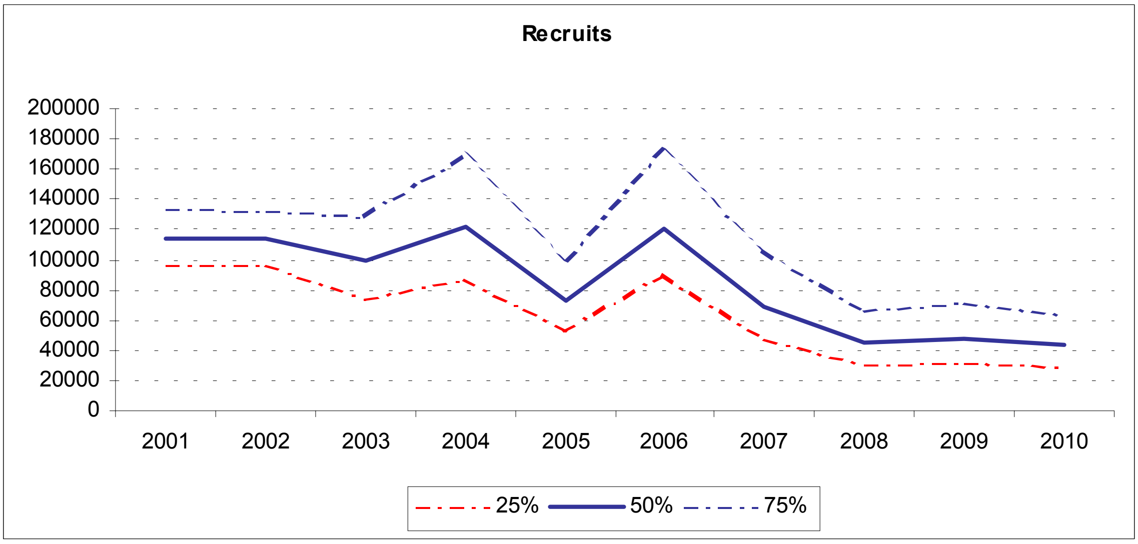


Figure 6.3.8. Medium-term projection results for Baltic cod.

D6, F = F_{SQ} = 1.07, Environment start year : 1993





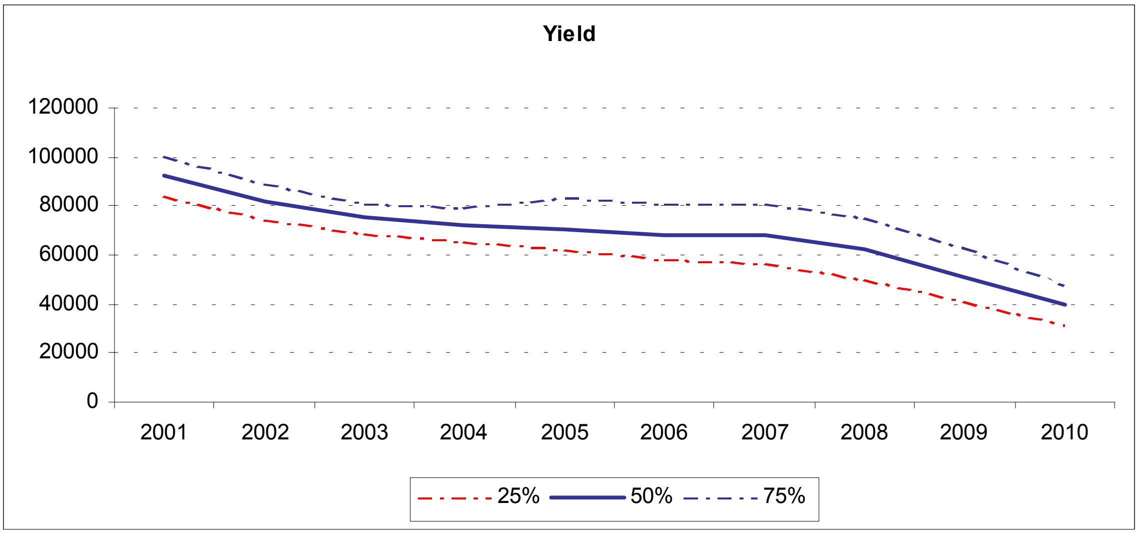
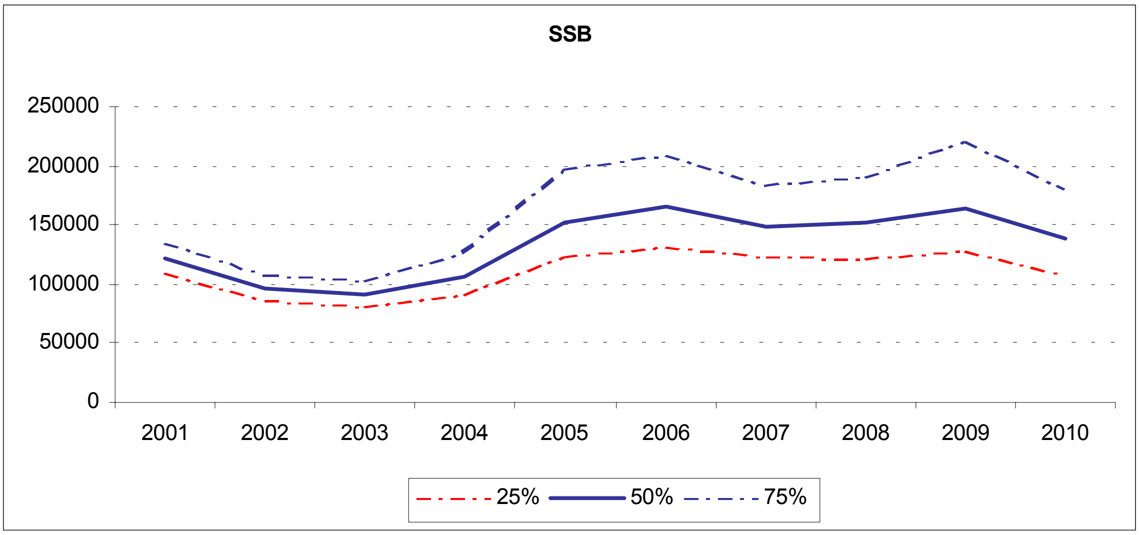
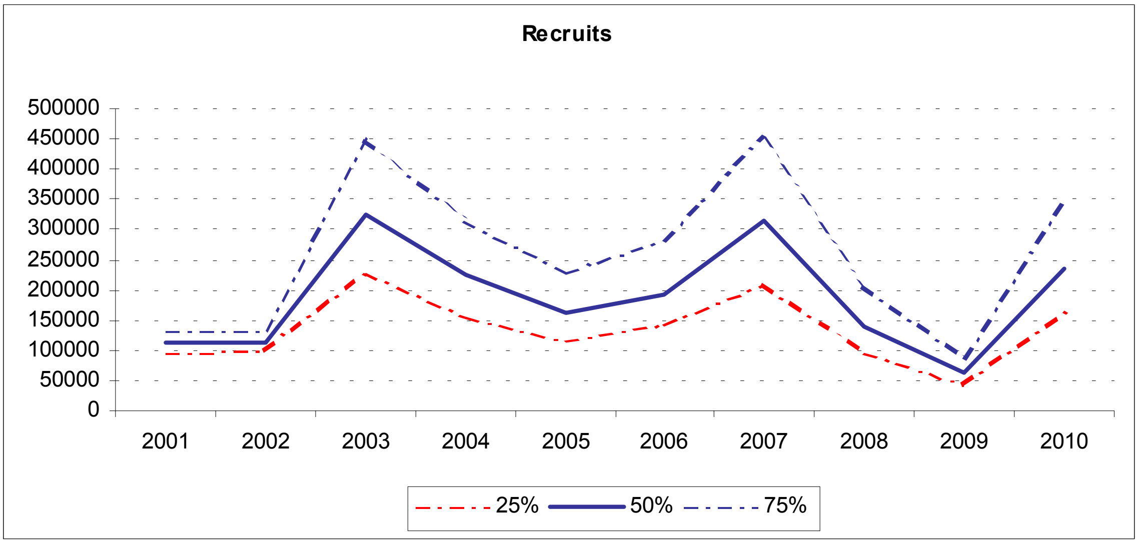


Figure 6.3.9. Medium-term projection results for Baltic cod.

D7, F = F_{SQ} = 1.07, Environment start year : 1976





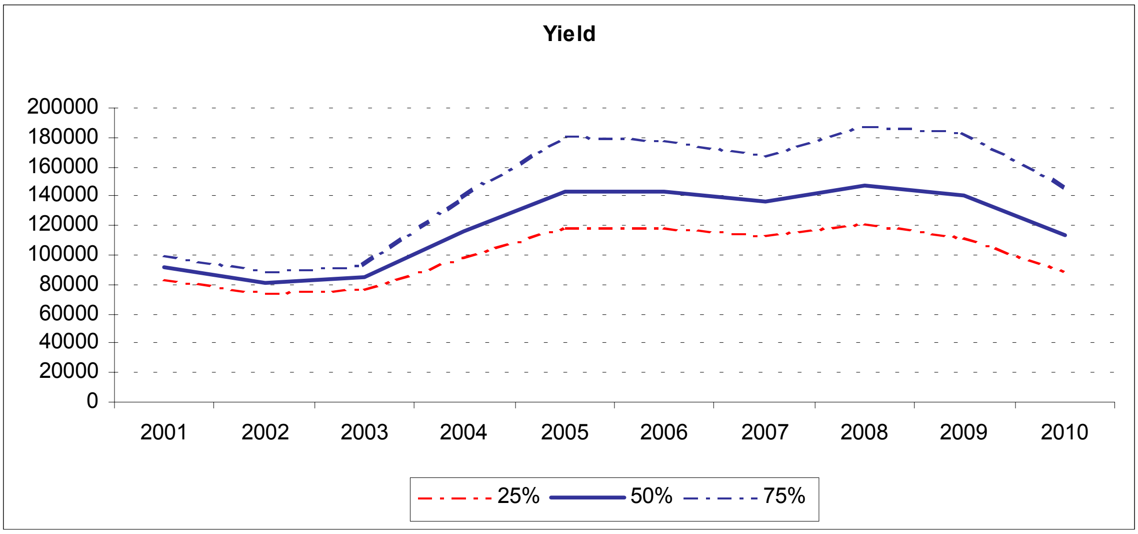
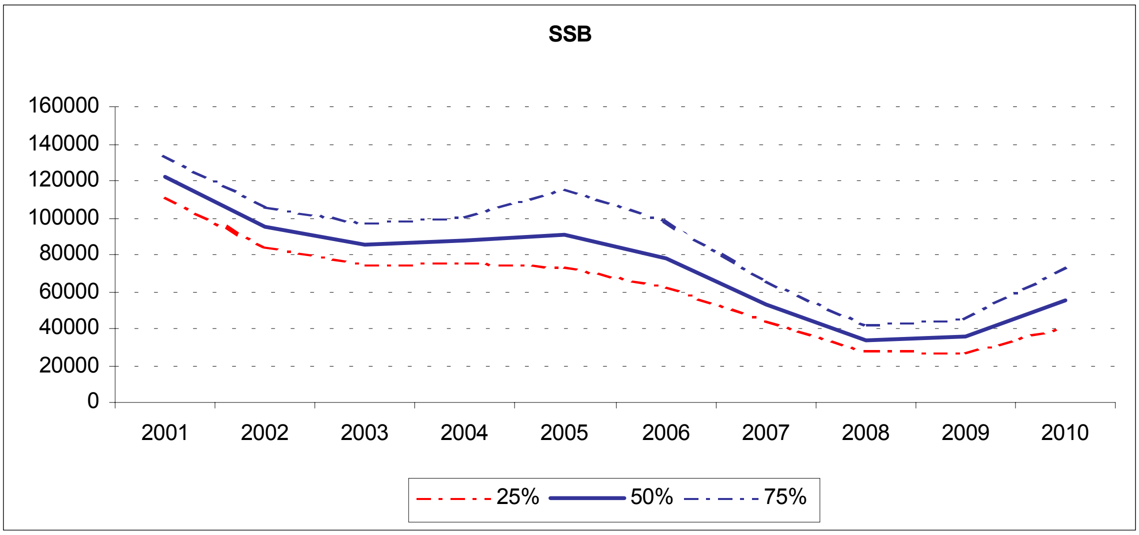
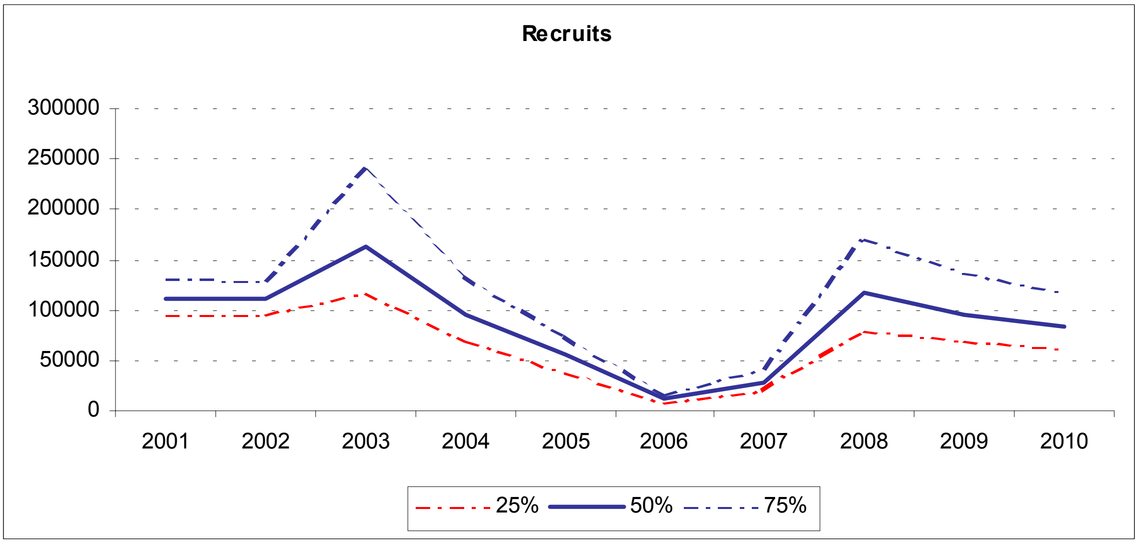


Figure 6.3.10: Medium-term projection results for Baltic cod.

D8, $F = F_{SQ} = 1.07$, Environment start year : 1986





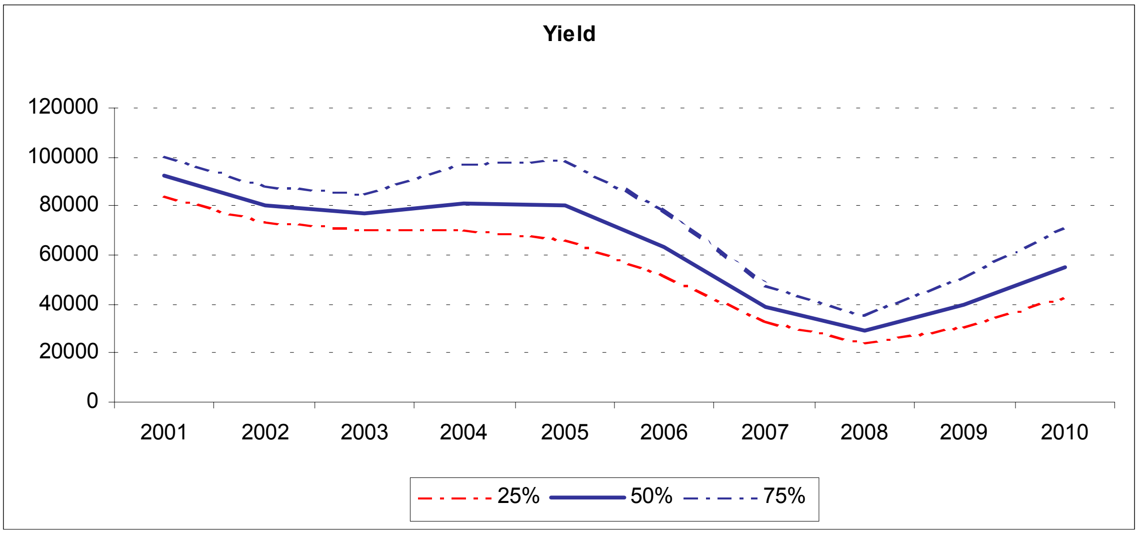
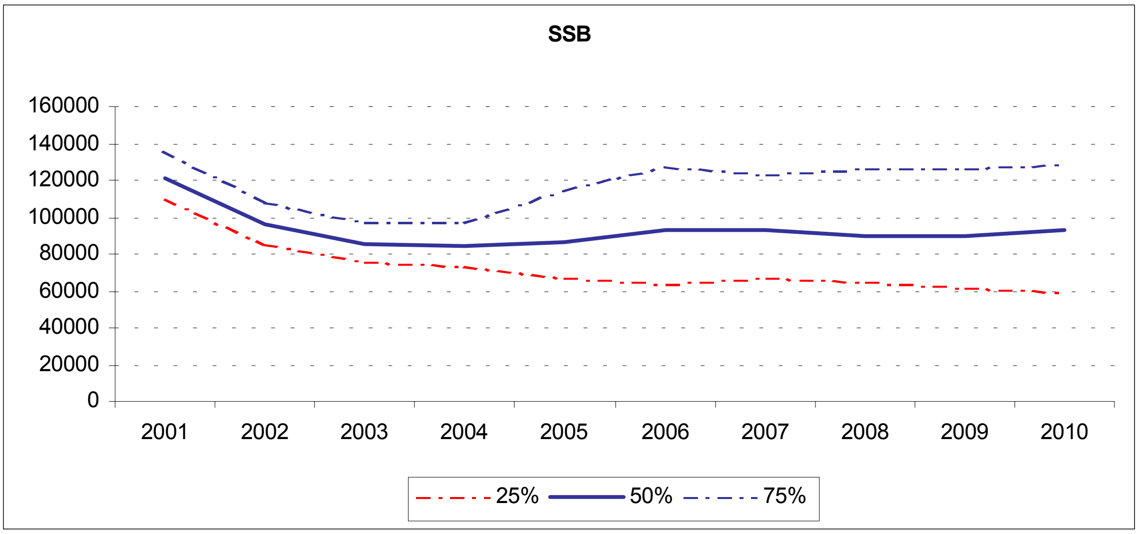
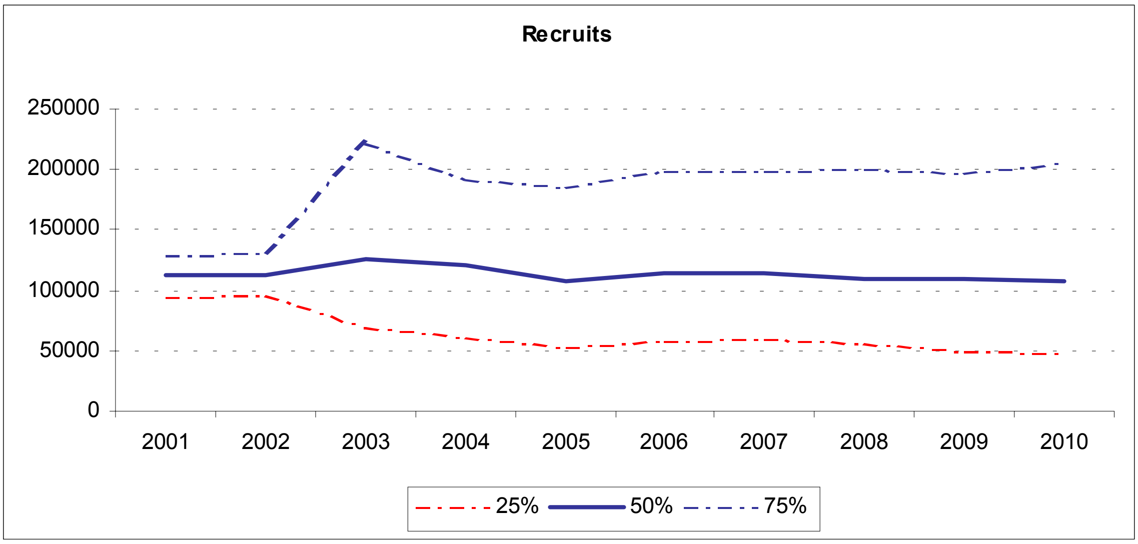


Figure 6.3.11. Medium-term projection results for Baltic cod.

D9, F = F_{SQ} = 1.07, Environment start year : Random





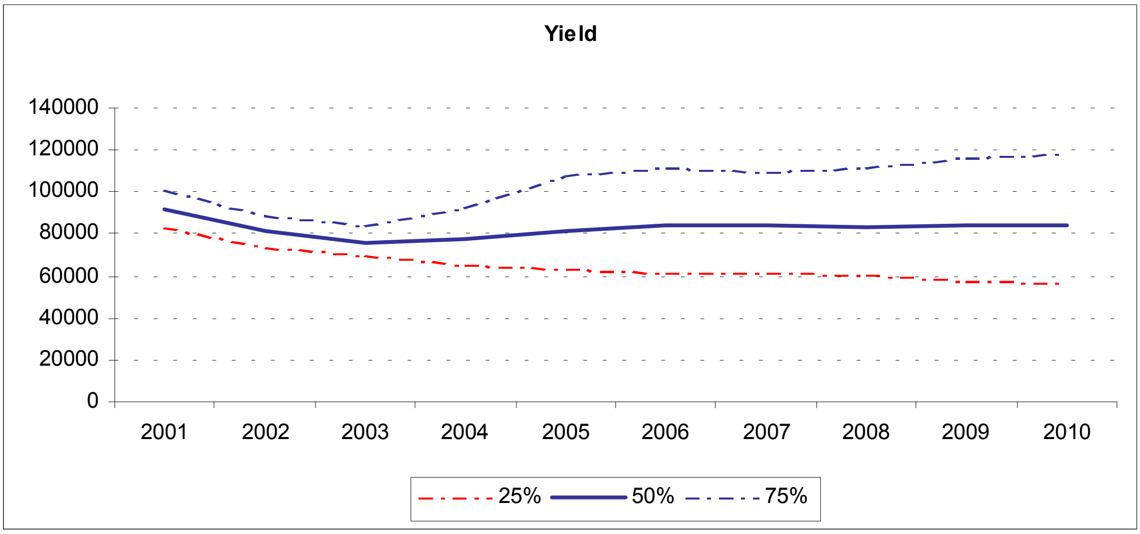
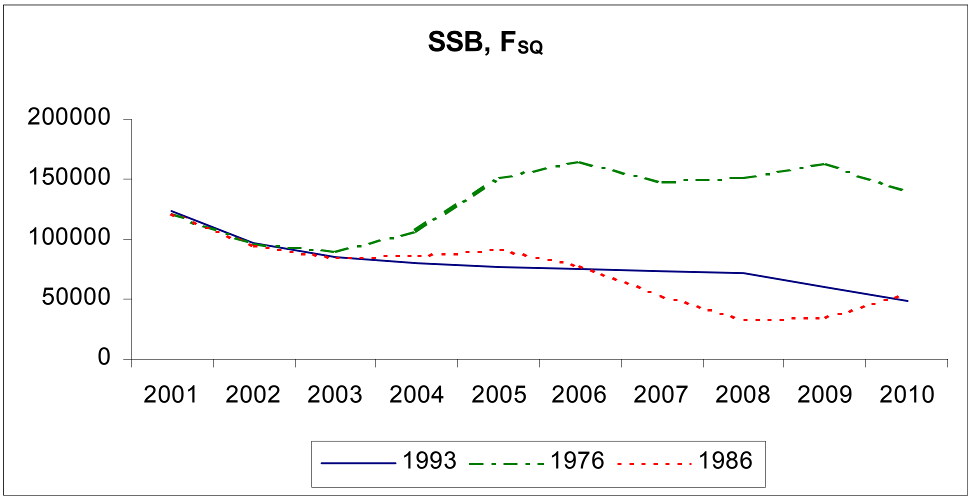
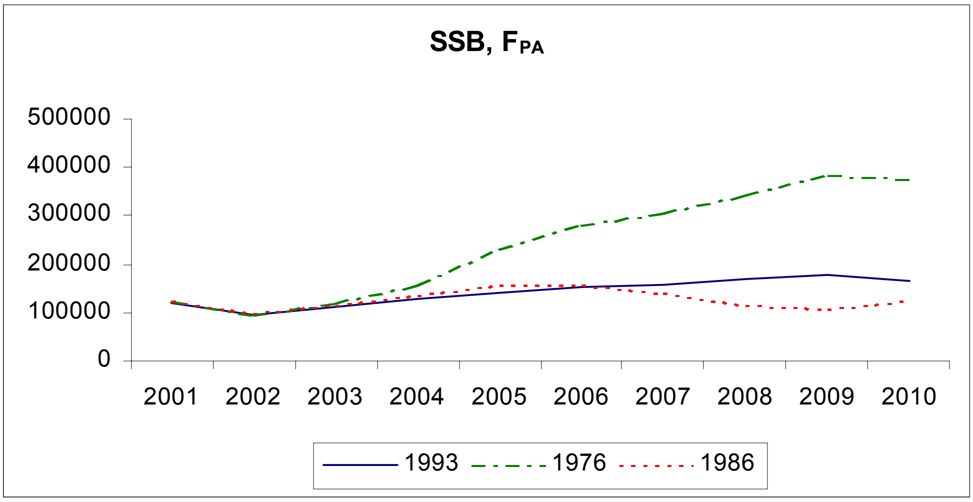


Figure 6.3.12. Medium-term projection results for Baltic cod.

50 percentiles of SSB from projections for fixed F but different environment scenarios





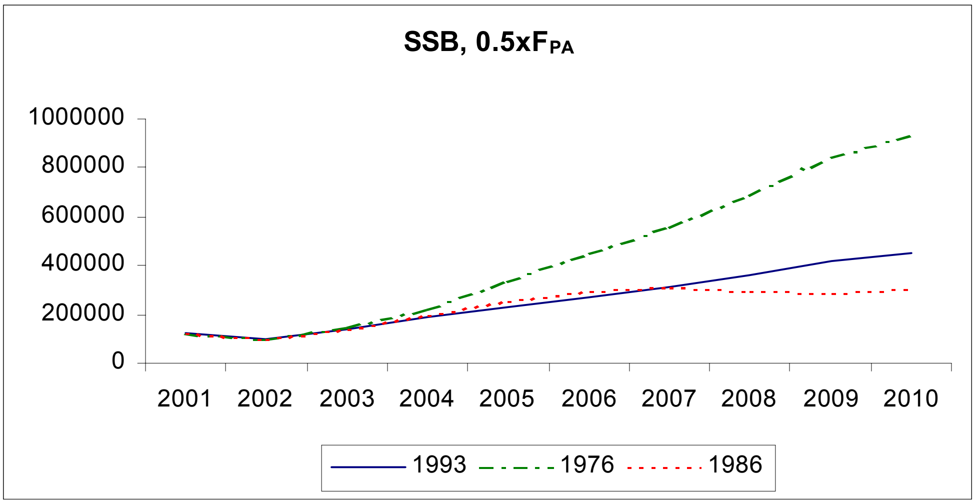
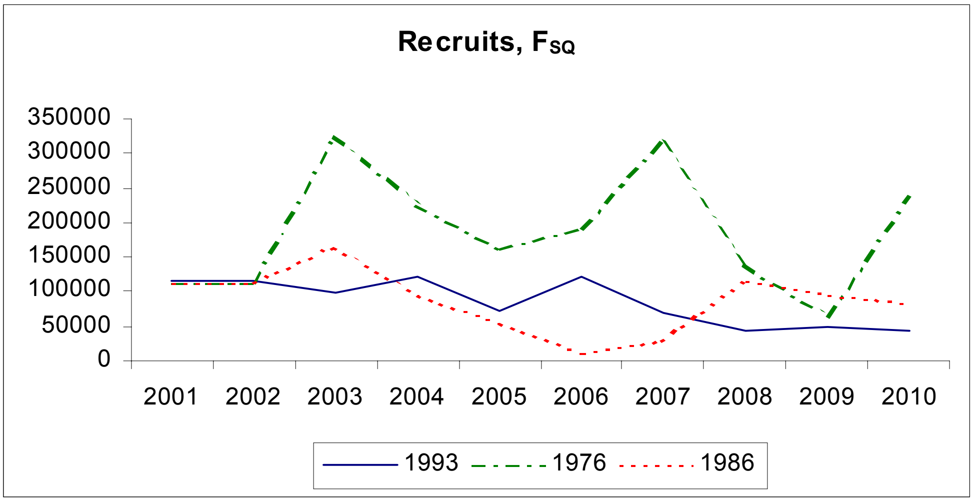
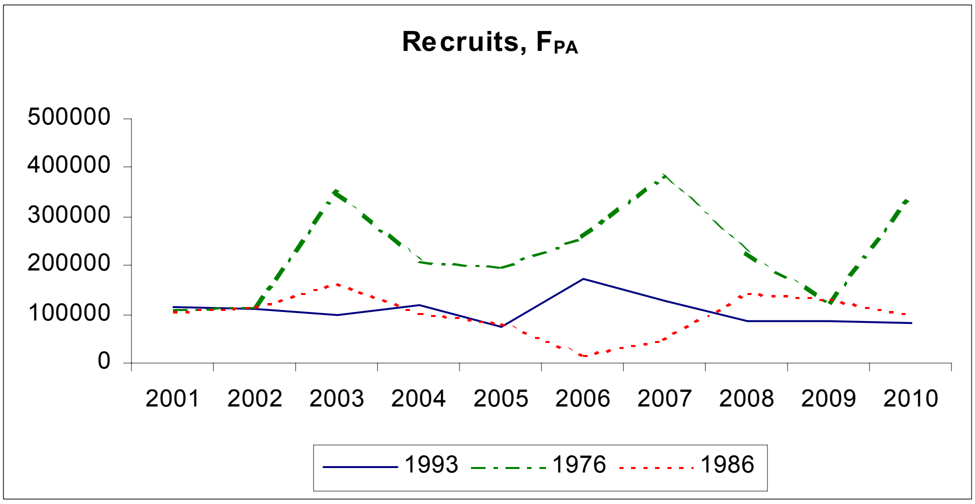


Figure 6.3.13. Medium-term projection results for Baltic cod.

50 percentiles of recruitment from projections for fixed F but different environment scenarios





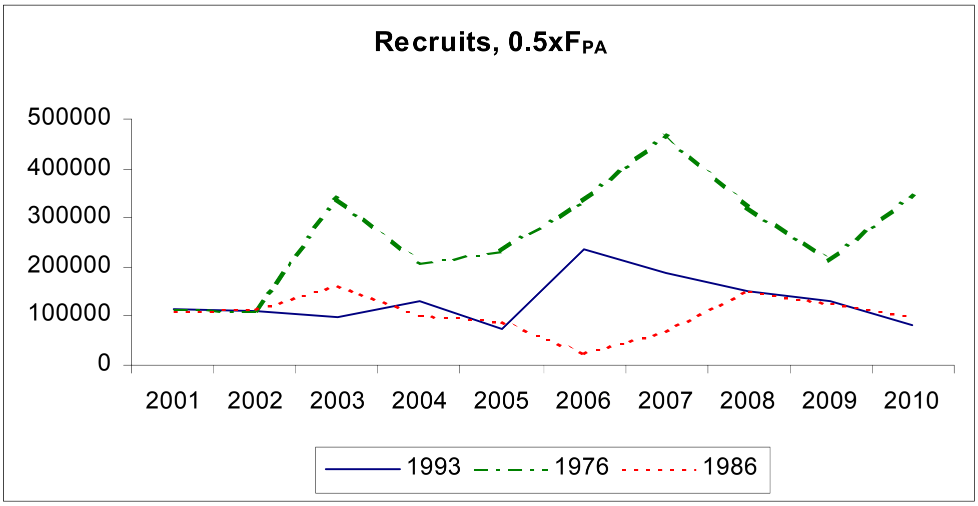
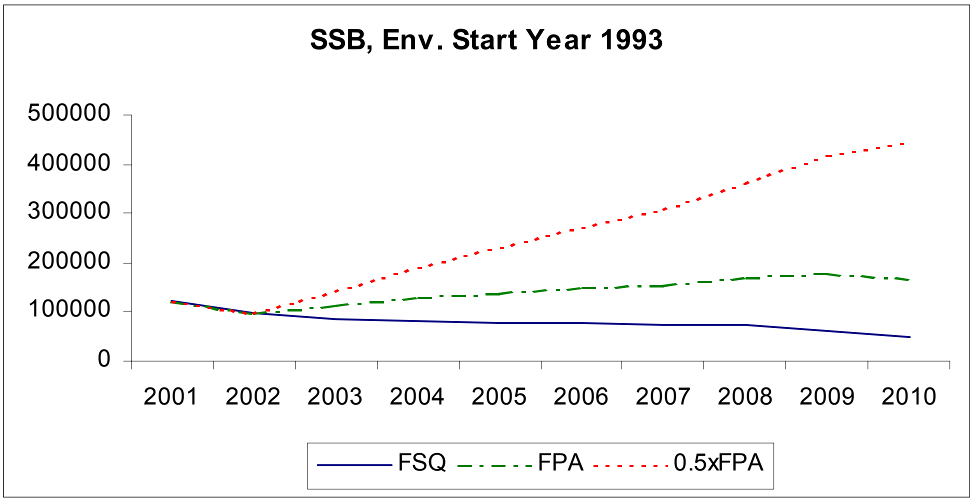
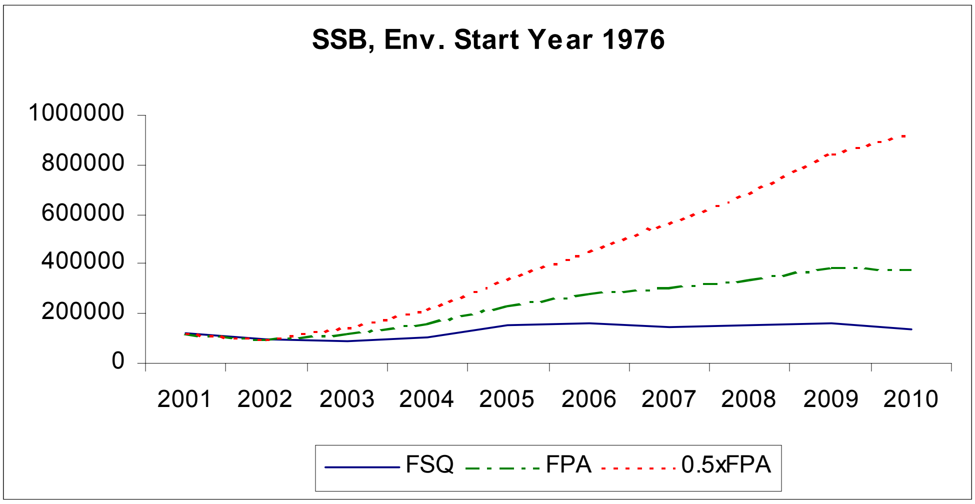


Figure 6.3.14. Medium-term projection results for Baltic cod.

50 percentiles of SSB from projections for the same environment scenarios, but different levels of fishing mortality





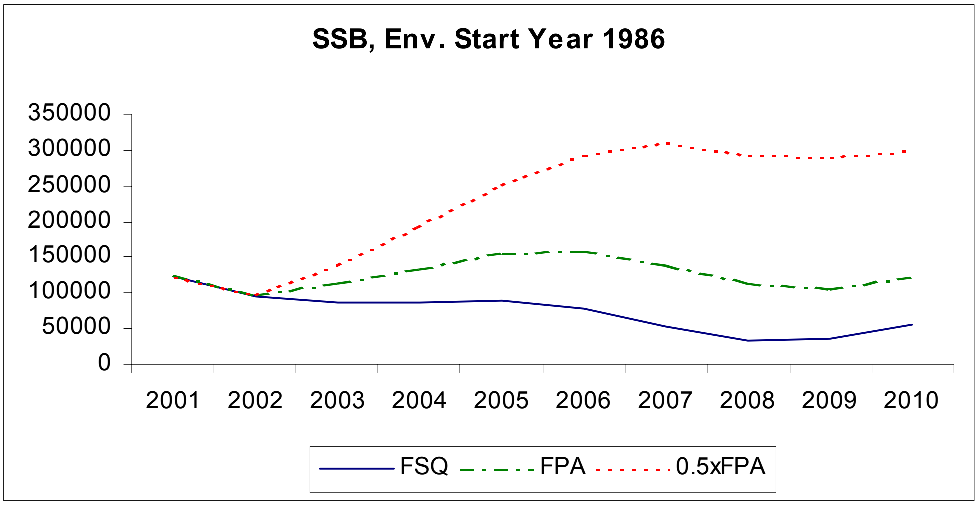
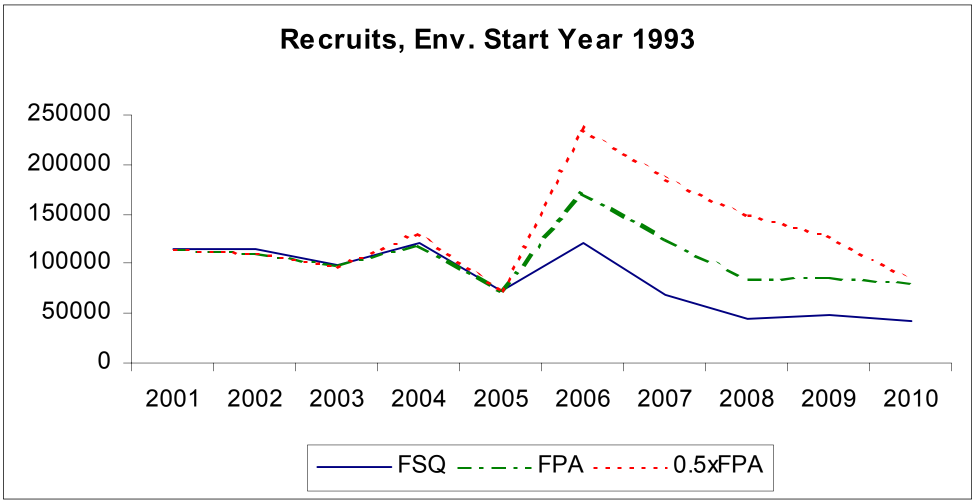
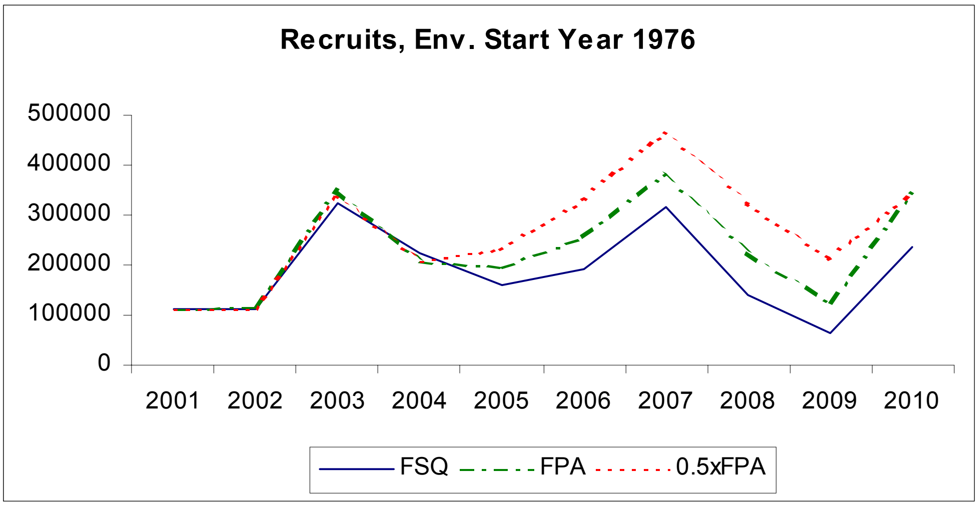


Figure 6.3.15. Medium-term projection results for Baltic cod.

50 percentiles of recruitment from projections for the same environment scenarios, but different levels of fishing mortality





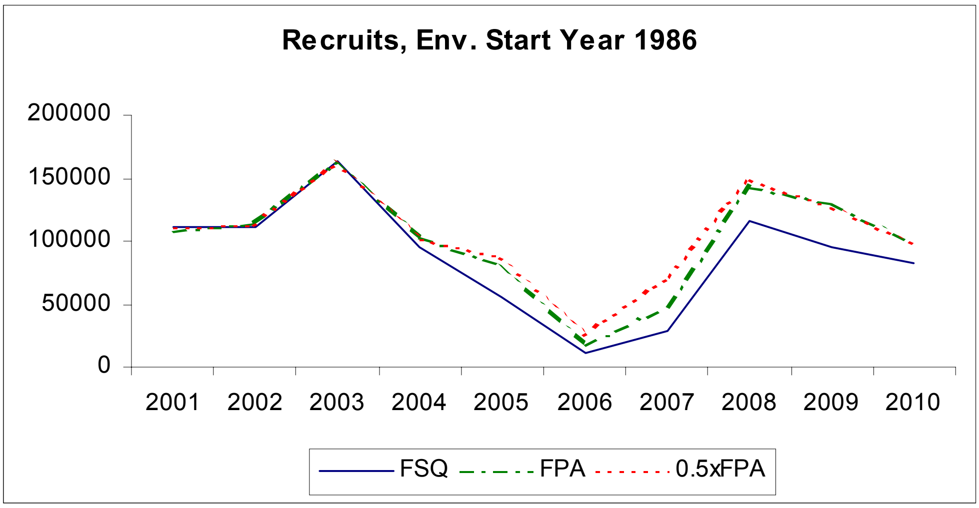


Figure 6.3.16. Medium-term projection results for Baltic cod.

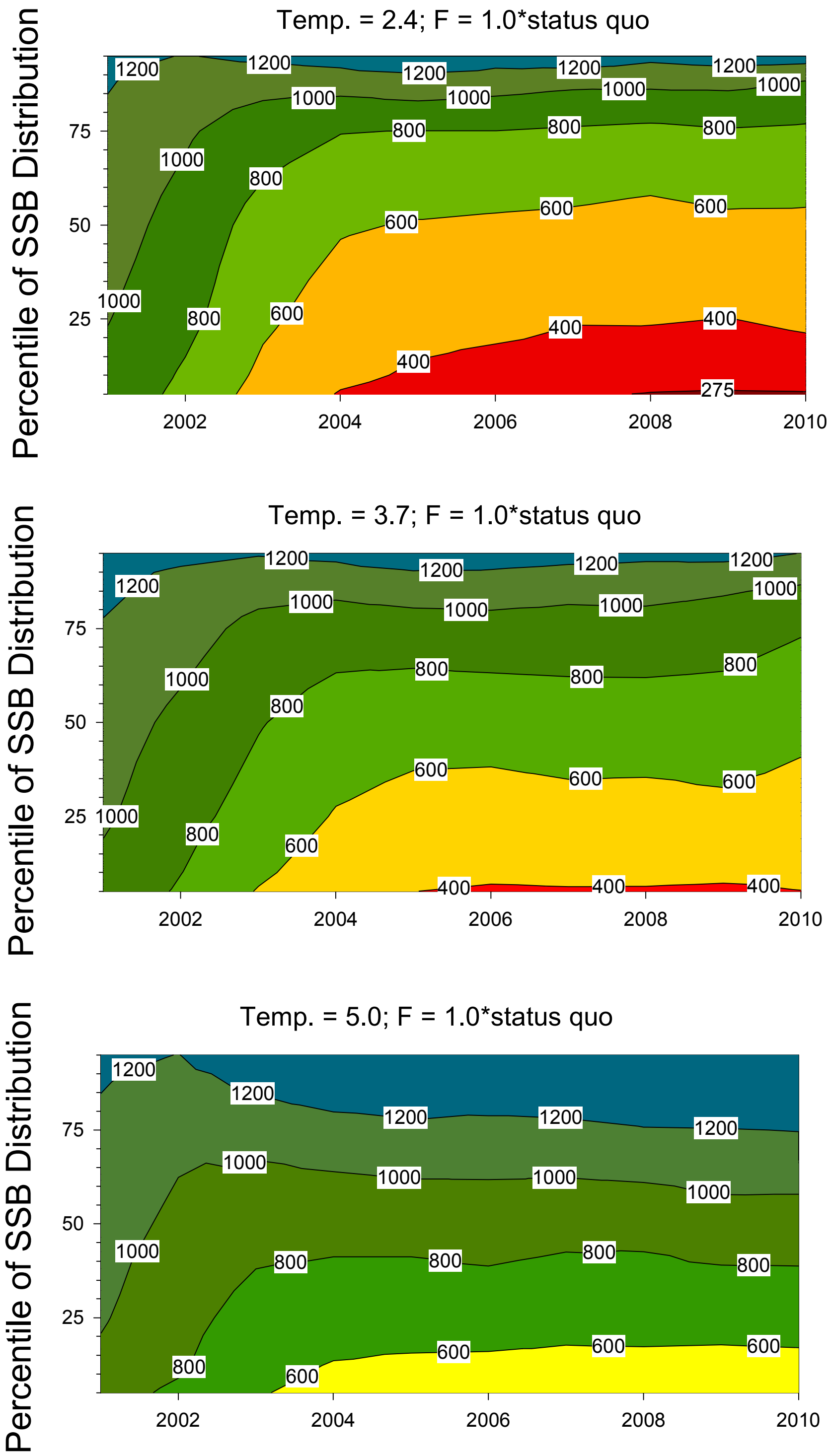


Fig. 6.3.17. Percentiles of simulated distributions of projected sprat spawner biomass (1000s t) under different temperature scenarios and assuming a hockey stick relationship between recruitment and spawner biomass with a break at 275000 to (B_{PA}). Exploitation rates are those observed in 1998-2000 (status quo).

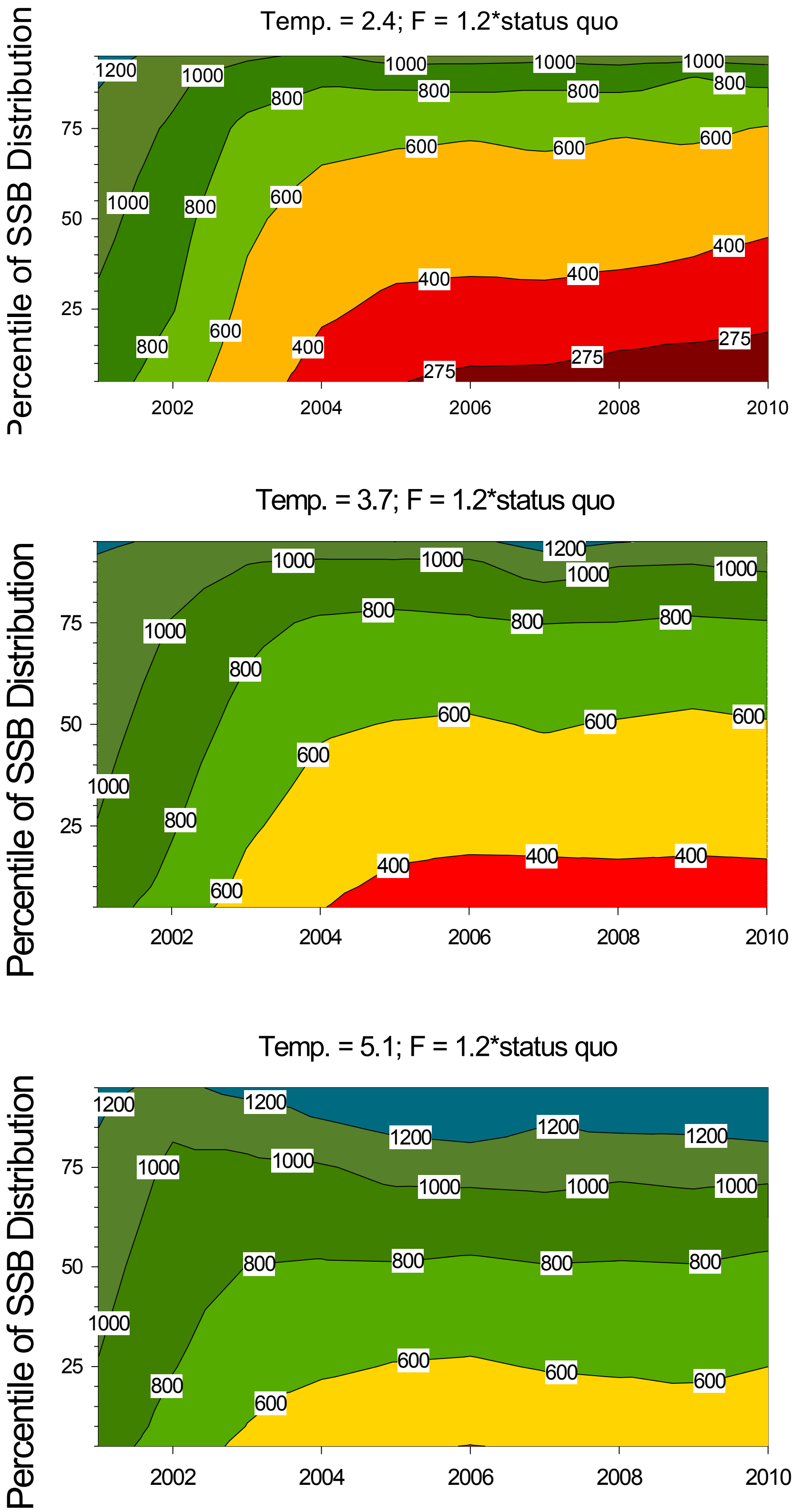


Fig. 6.3.18. Percentiles of simulated distributions of projected sprat spawner biomass (1000s t) under different temperature scenarios with exploitation rates 20% higher than those observed in 1998-2000 (i.e., 1.2*status quo). Calculations assume a hockey stick relationship between recruitment and spawner biomass with a break at 275000 to (B_{PA}).

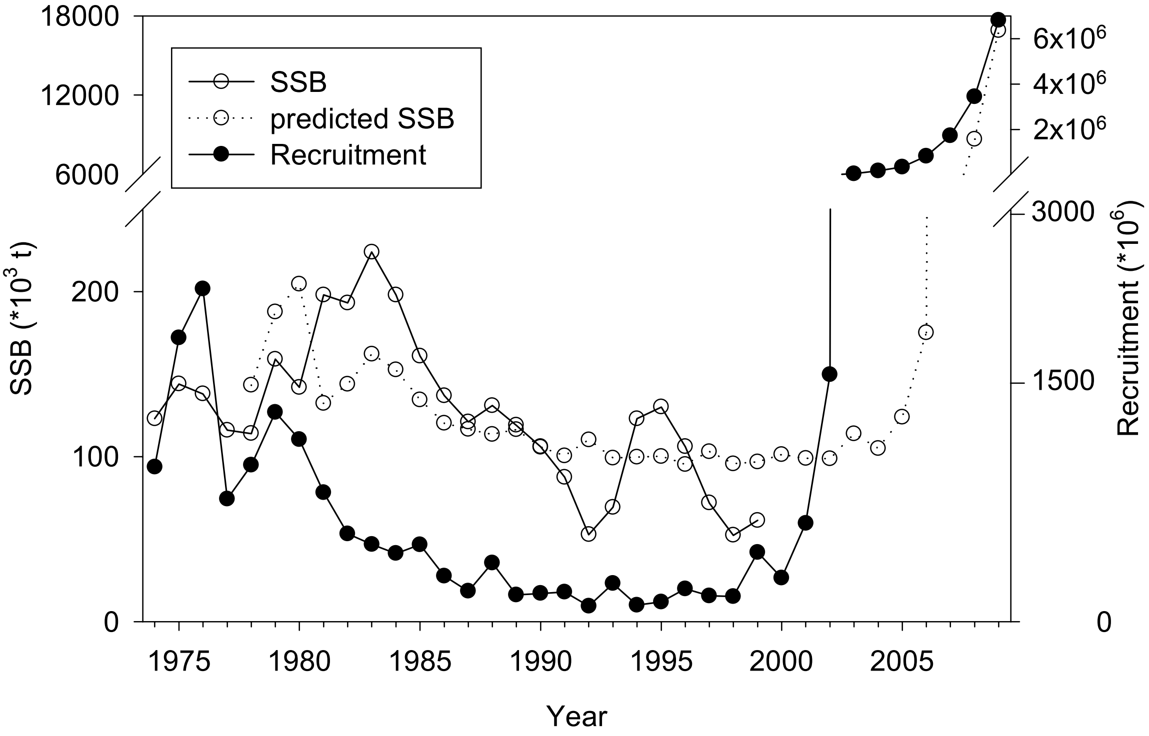


Fig. 6.3.19. Observed cod SSB (1974-1999) predicted SSB (1974-2009) by GLM from recruitment at age 1 lagged 4 years, with recruitment predicted by environmentally sensitive GLM stock recruitment relationship based on ARIMA model predictions of environments in 2000-2009.

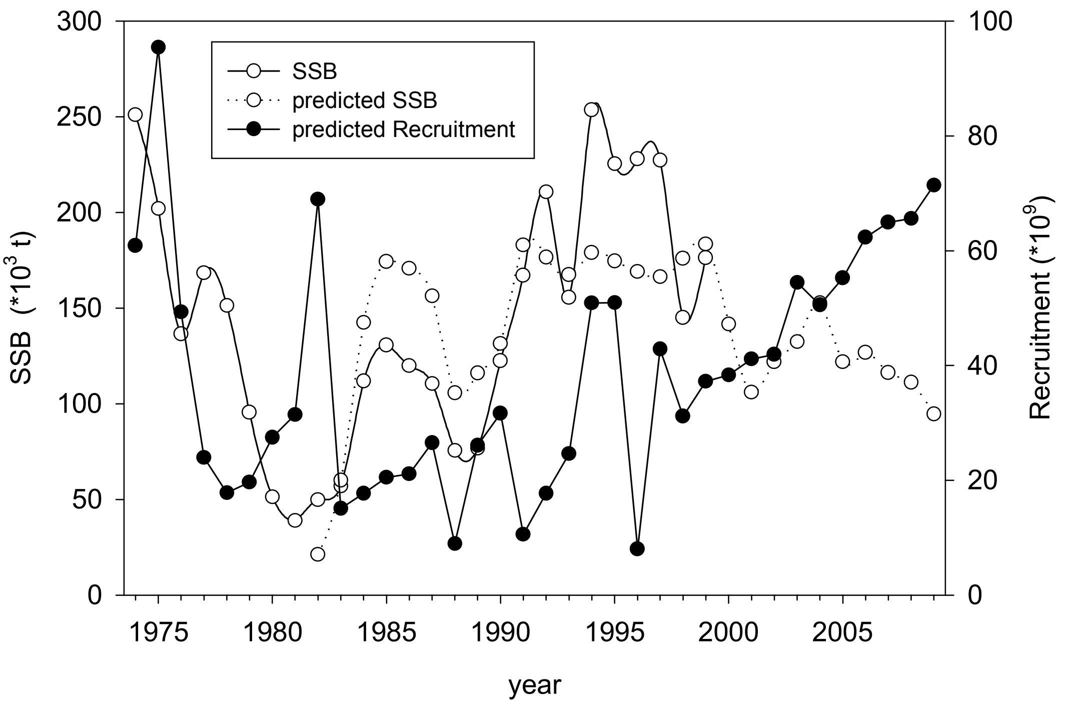


Fig. 6.3.20. Observed sprat SSB (1974-1999) predicted SSB (1974-2009) by GLM from recruitment at age 1 lagged 4 years, with recruitment predicted by environmentally sensitive GLM stock recruitment relationship based on ARIMA model predictions of environments in 2000-2009.

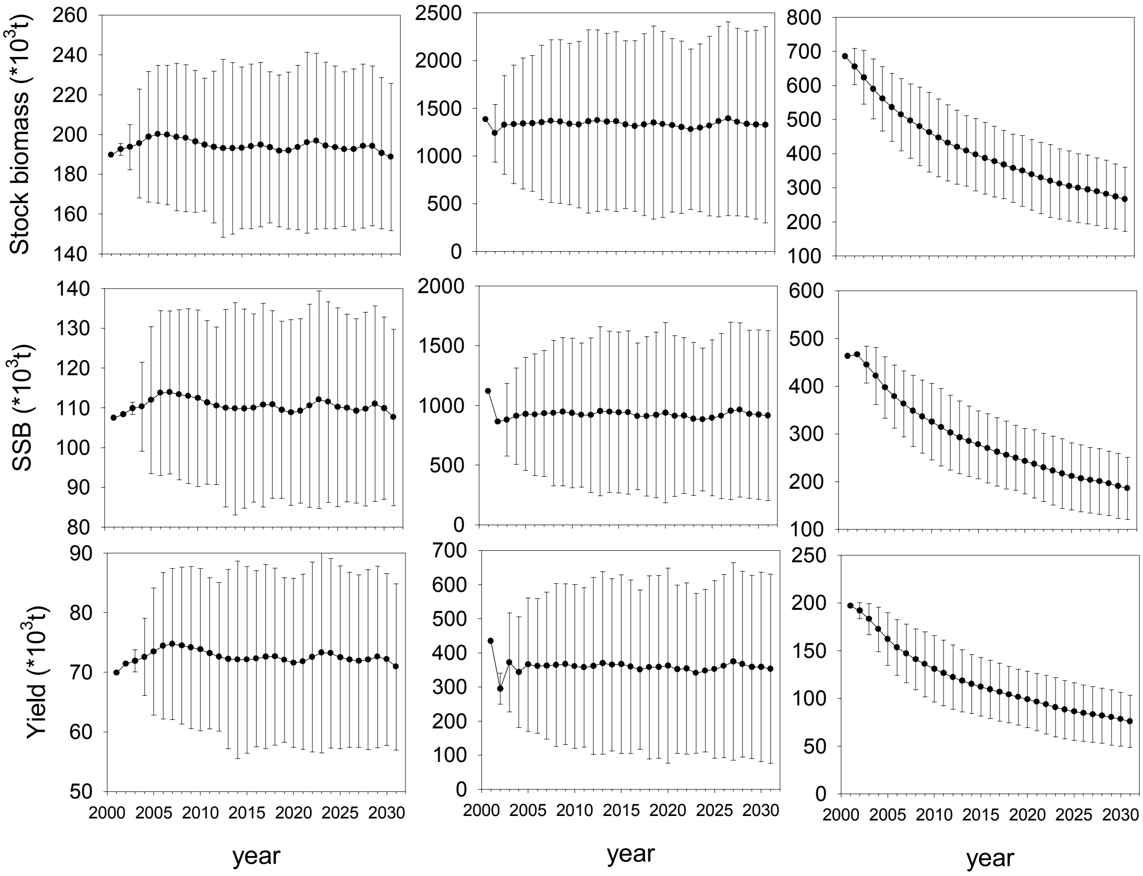


Fig. 6.3.21. Key-run prediction of total stock biomass, SSB and yield for cod (1 st row), sprat (2nd row) and herring (3rd row).

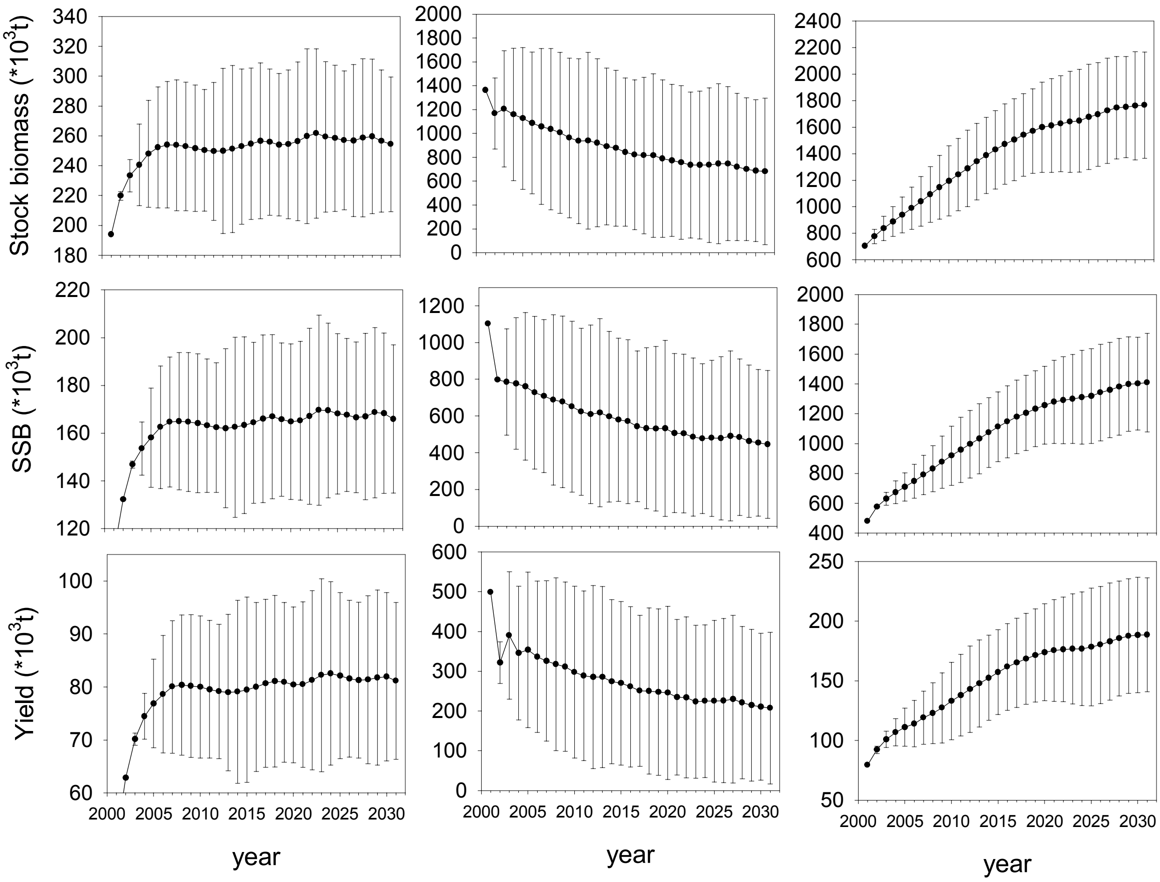


Fig. 6.3.22. Fpa based prediction of total stock biomass, SSB and yield for cod (1 st row), sprat (2nd row) and herring (3rd row).

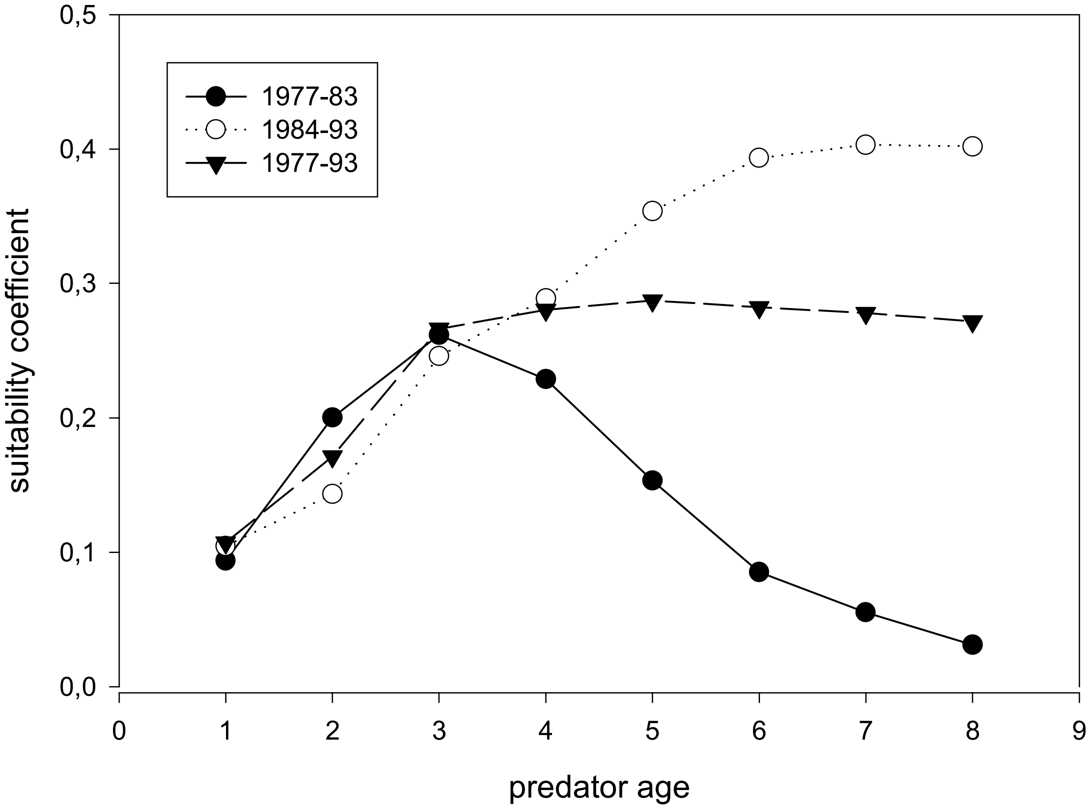


Fig. 6.3.23. Suitability coefficients of Baltic cod age-group 0 as prey of predatory cod age-groups 1-8 (averages over quarters), determined with different sets of stomach content data: 1977-1983 encompassing the period of high and 1984-1993 the period of low occurrence of cod in cod stomachs, as well as the entire period used in standard MSVPA.

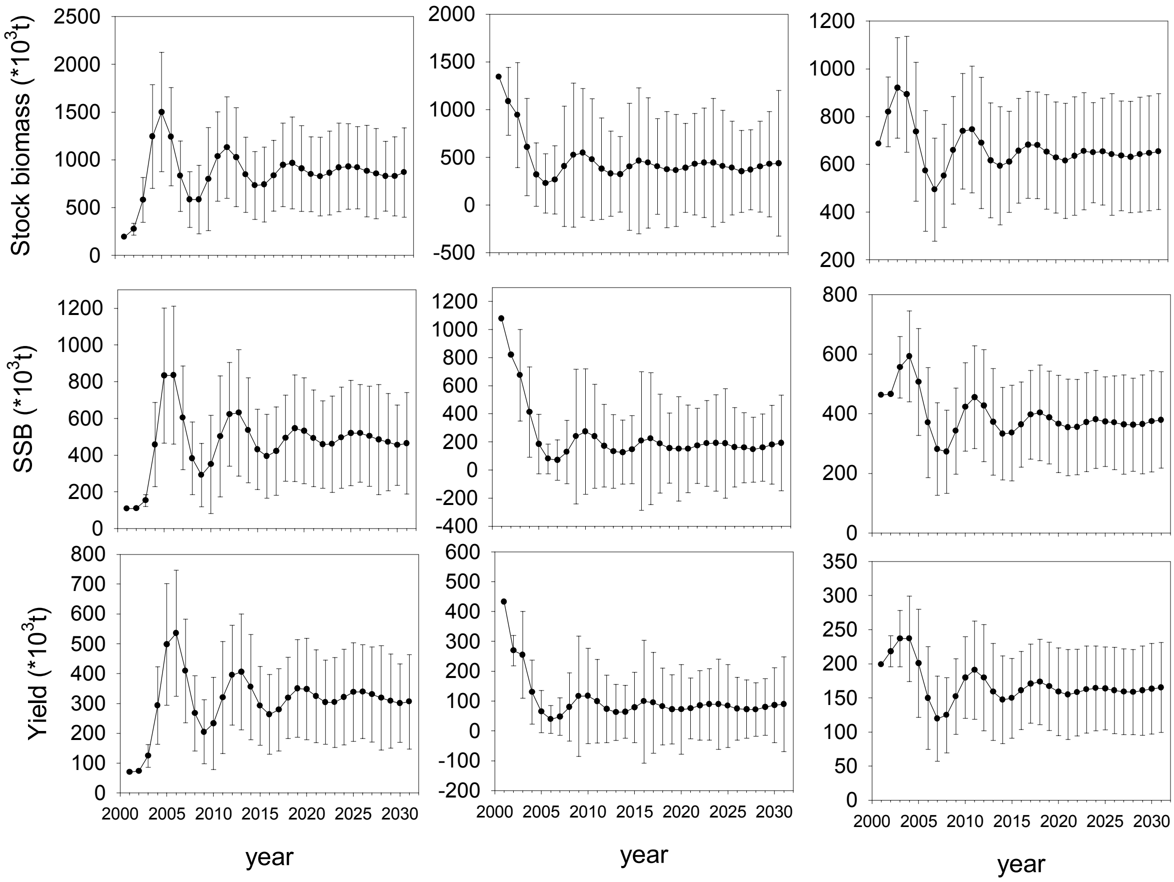


Fig. 6.3.24. “High cod stock” prediction of total stock biomass, SSB and yield for cod (1 st row), sprat (2nd row) and herring (3rd row).

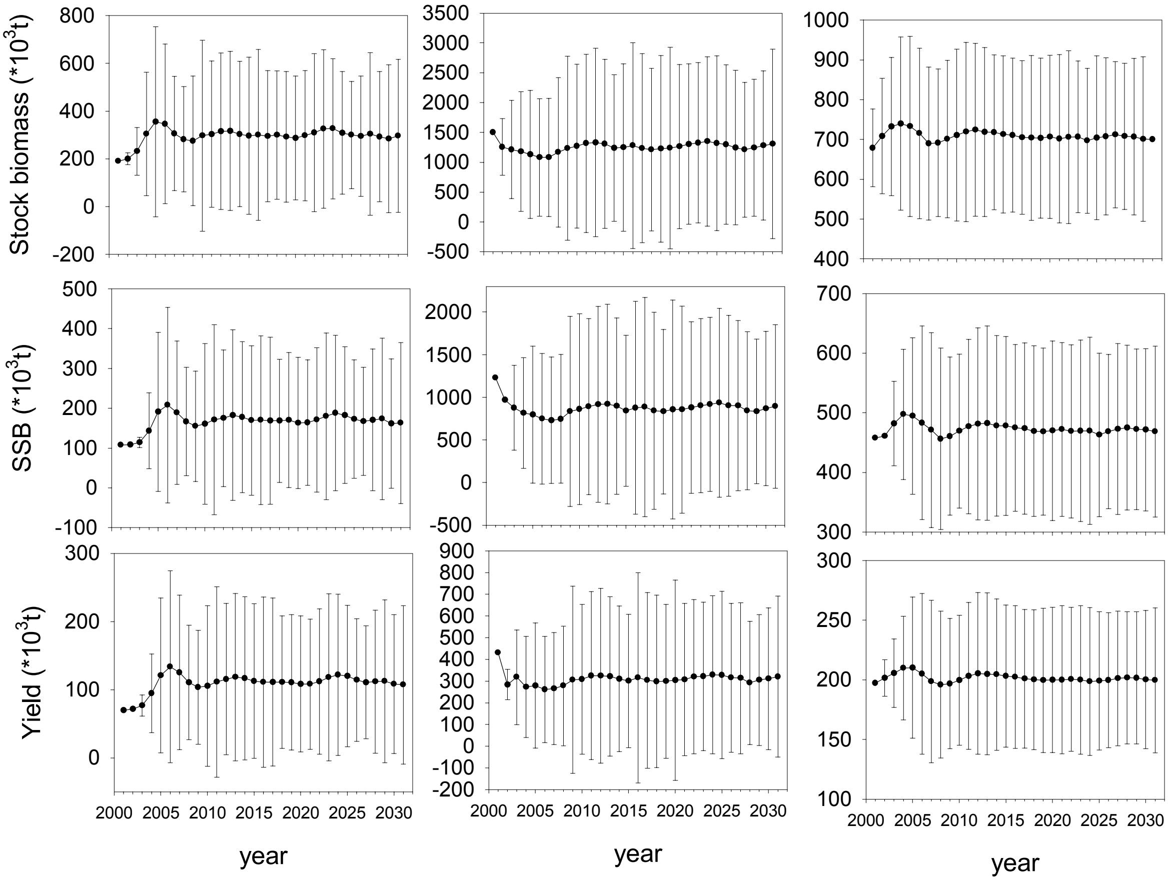
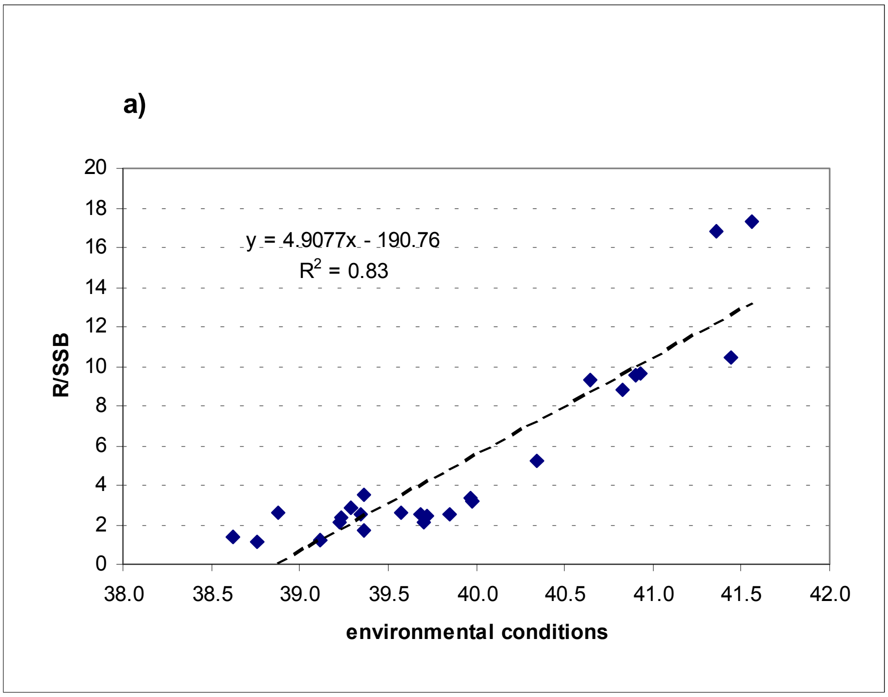


Fig. 6.3.25. “Low cod stock” prediction of total stock biomass, SSB and yield for cod (1 st row), sprat (2nd row) and herring (3rd row).



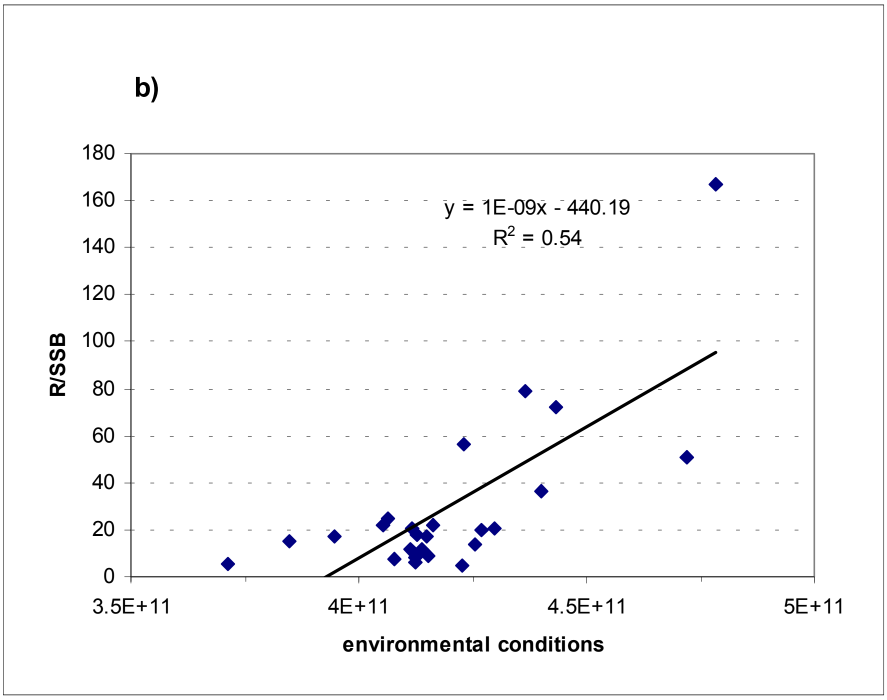


Fig. 6.3.26. Dependence of recruitment per spawning biomass (R/SSB) on the index of environmental conditions for cod (a) and sprat (b).

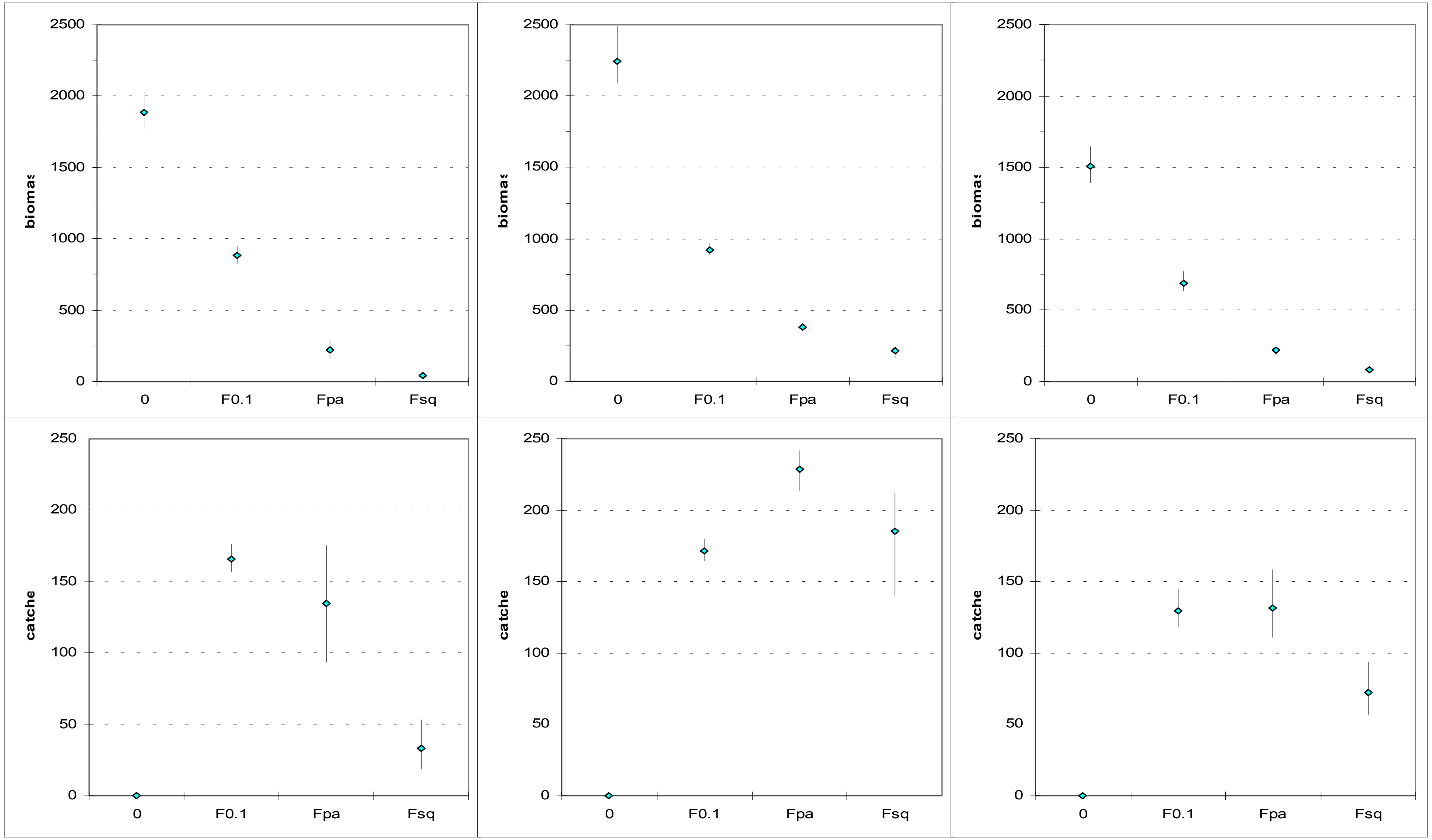


Fig. 6.3.27. Summary of medium-term simulations for the eastern Baltic cod using the multispecies production model. Biomass (age 3+) and catches ('000 tons) at selected levels of fishing mortality for low (1st row) and high (2nd row) environmental conditions. The 3rd row presents the simulation with the standard stock-recruitment relationship. Whiskers show the 25th and 75th percentile of the biomass/catch distribution.

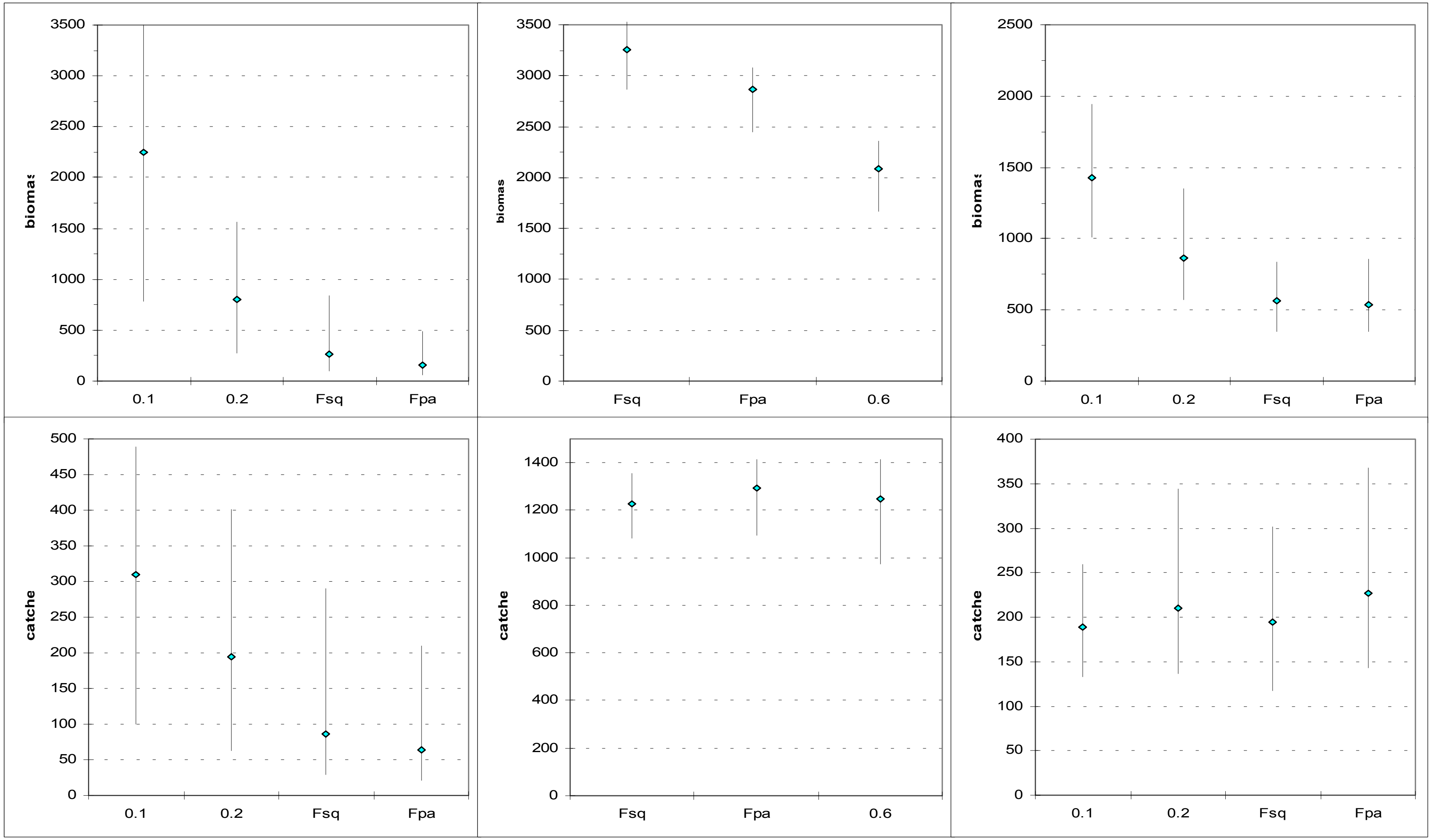


Fig. 6.3.28. Summary of medium-term simulations for the Baltic sprat using the multispecies production model. Biomass (age 2+) and catches ('000 tons) at selected levels of fishing mortality for low (left panels) and high (mid panels) environmental conditions. The right panels presents the simulation with standard stock-recruitment relationship. For cod fishing at Fpa and low environmental conditions have been assumed. Whiskers show the 25th and 75th percentile of the biomass/catch distribution.

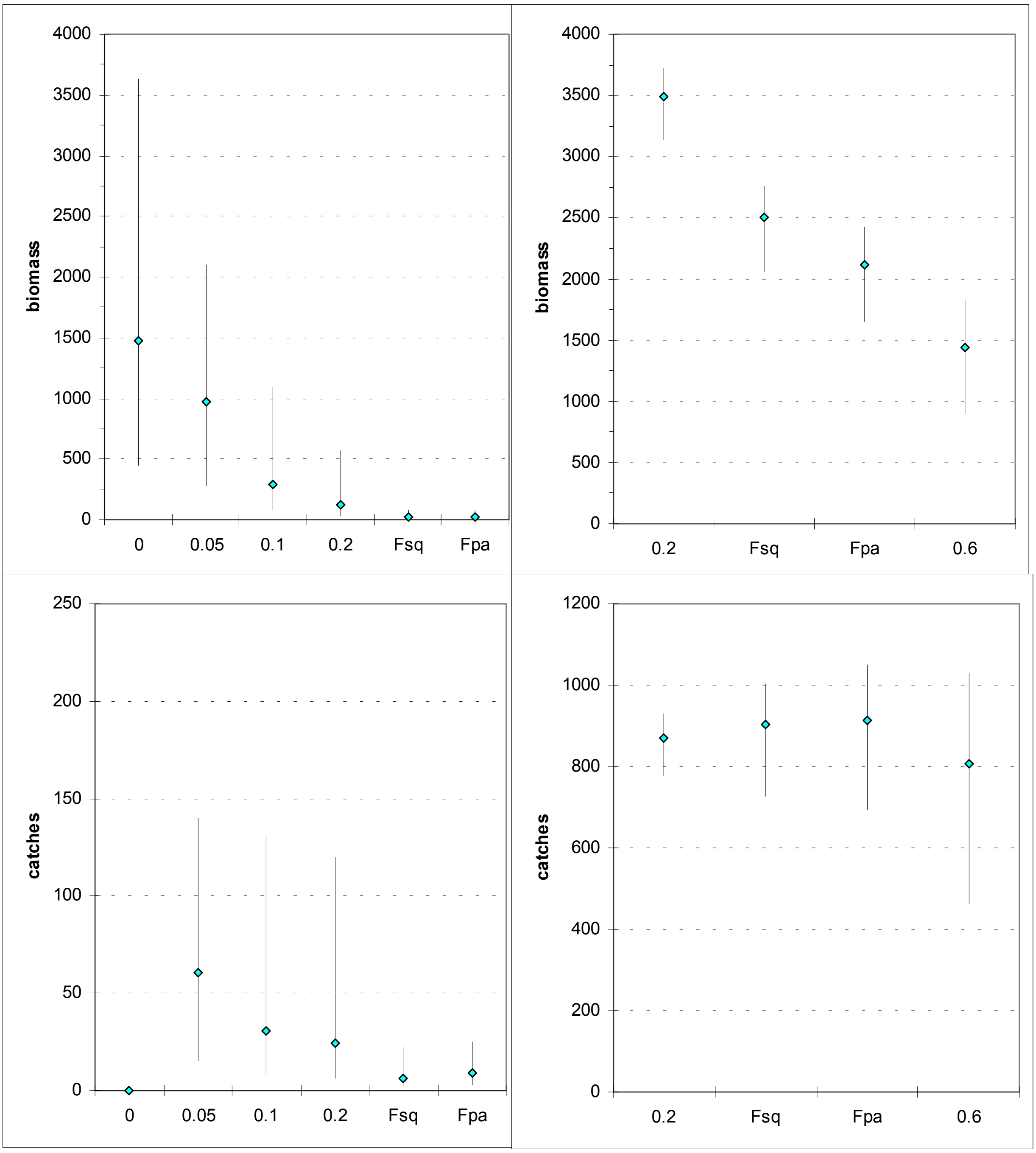


Fig. 6.3.29. Summary of medium-term simulations for Baltic sprat using the multispecies production model. Biomass (age 2+) and catches ('000 tons) at selected levels of fishing mortality for low (left panels) and high (right panels) environmental conditions. For cod fishing at Fpa and high environmental conditions have been assumed. Whiskers show the 25th and 75th percentile of the biomass/catch distribution.

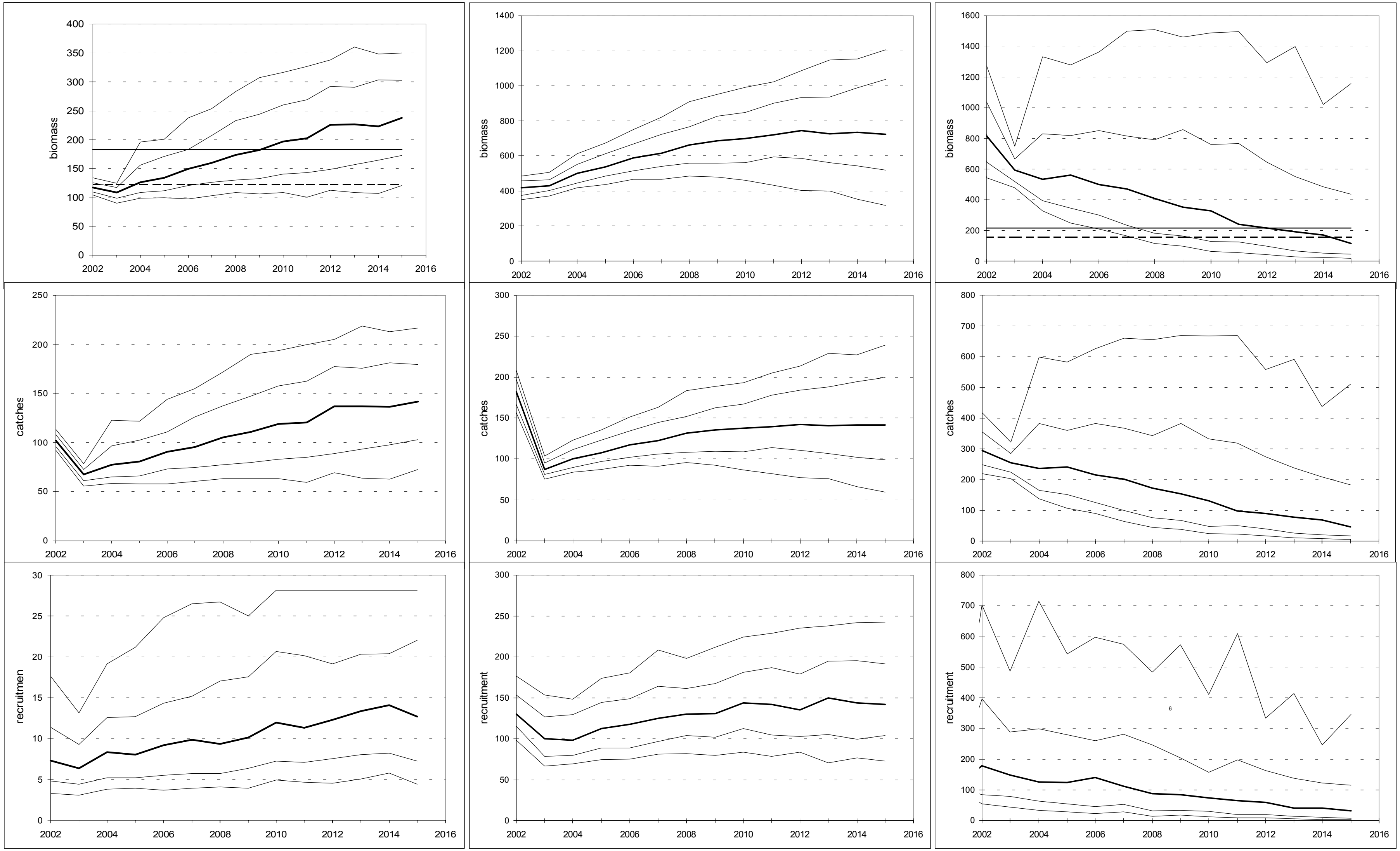


Fig. 6.3.30. Medium-term simulations using multispecies production model. Lines show the 10, 25, 50, 75 and 90th percentile of biomass, catch and recruitment distributions for cod (left panels), herring (middle panels) and sprat (right panels). Parallel lines indicate Blim and Bpa (values rescaled to the biomass estimates from production model). Assumed low environmental conditions for both cod and sprat. All species exploited at Fpa.

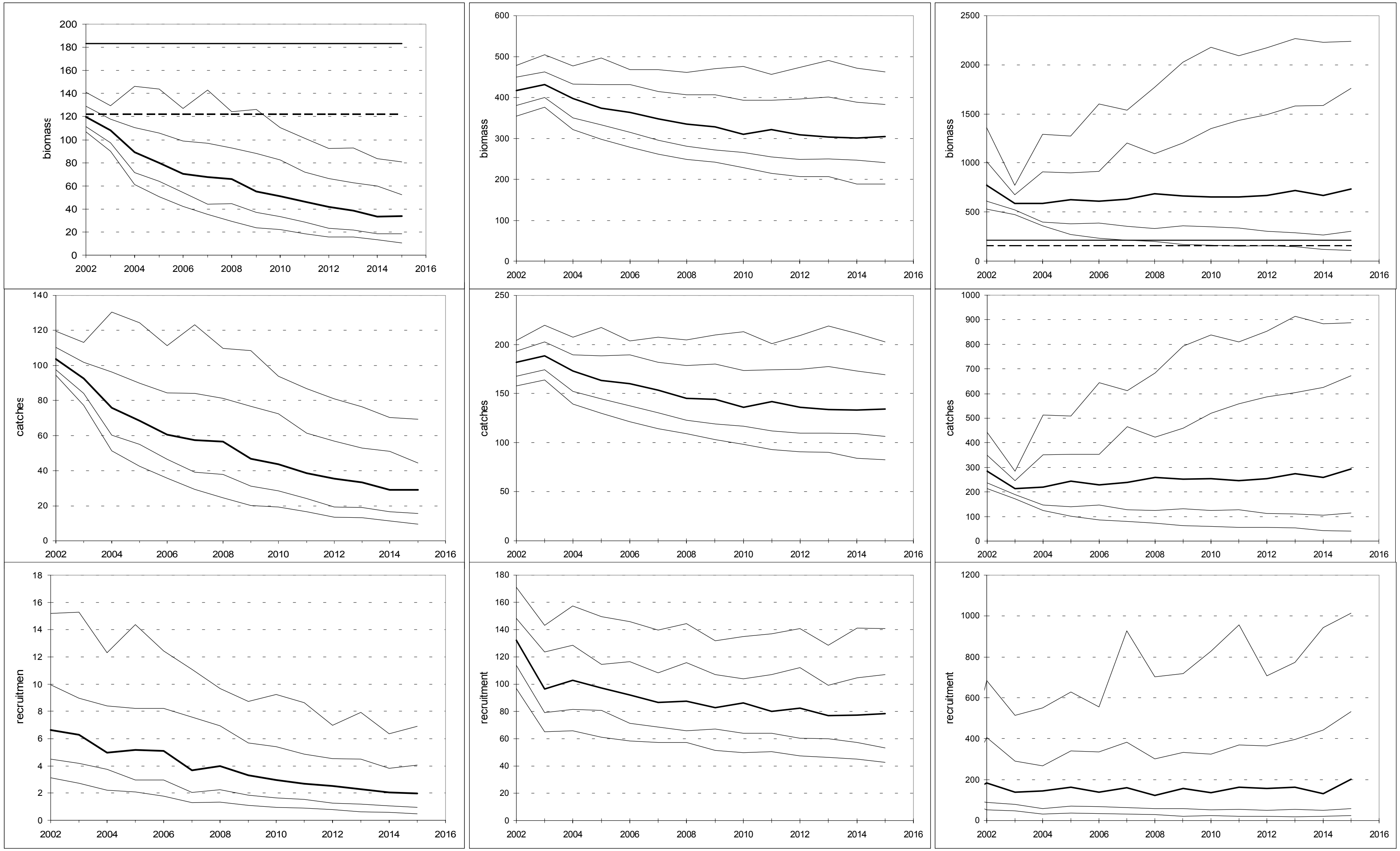


Fig. 6.3.31. Medium-term simulations using the multispecies production model. Lines show the 10, 25, 50, 75, and 90th percentile of the biomass, catch, and recruitment distributions for cod (left panels), herring (mid panels) and sprat (right panels). Parallel lines indicate Blim and Bpa (values rescaled to the biomass estimates from the production model). Assumed low environmental conditions for both cod and sprat. All species exploited at Fsq.

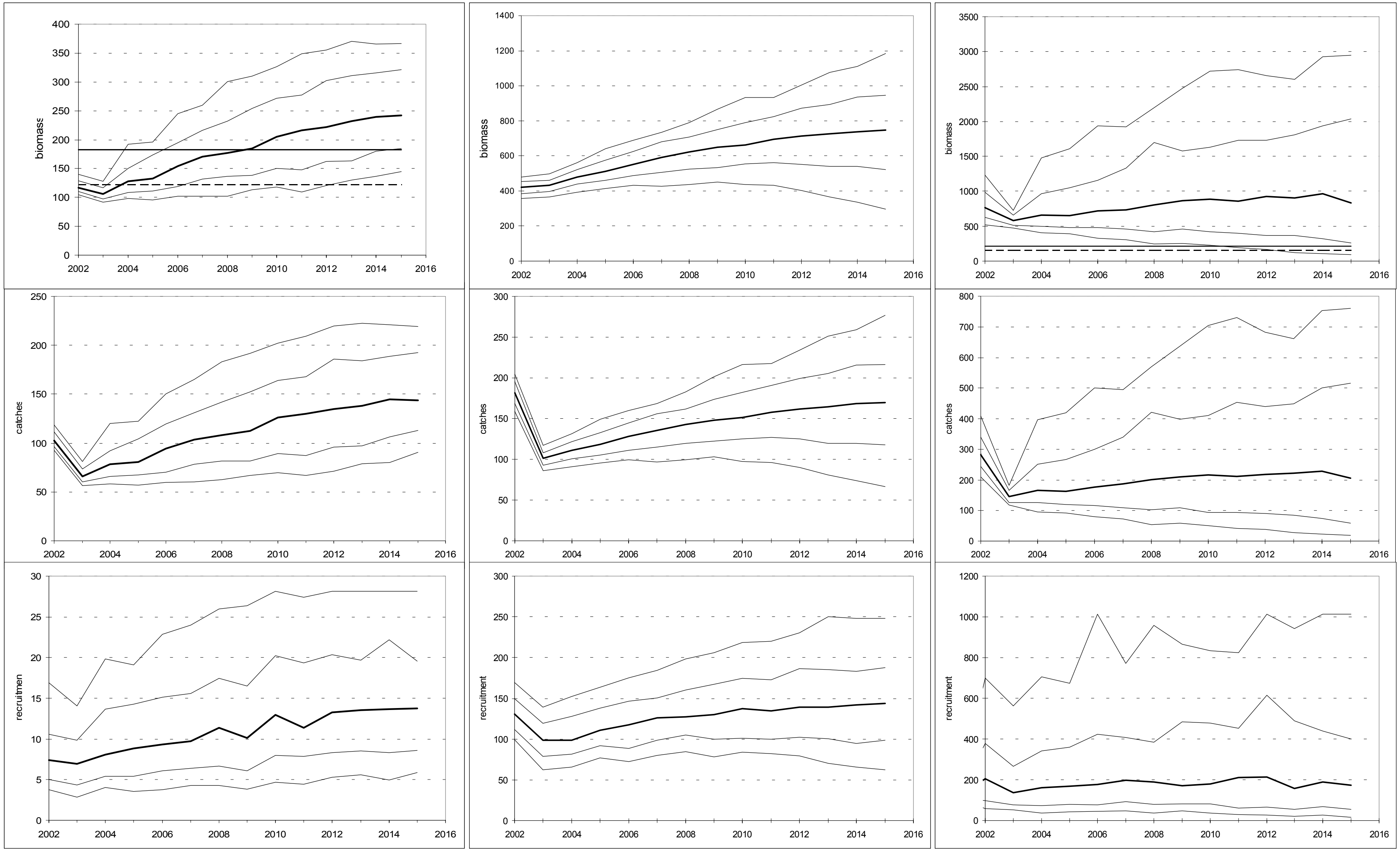


Fig. 6.3.32. Medium-term simulations using multispecies the production model. Lines show the 10, 25, 50, 75, and 90th percentile of the biomass, catch and recruitment distributions for cod (left panels), herring (mid panels) and sprat (right panels). Parallel lines indicate Blim and Bpa (values rescaled to the biomass estimates from the production model). Assumed low environmental conditions for both cod and sprat. Cod exploited at Fpa, sprat and herring at F of 0.2.

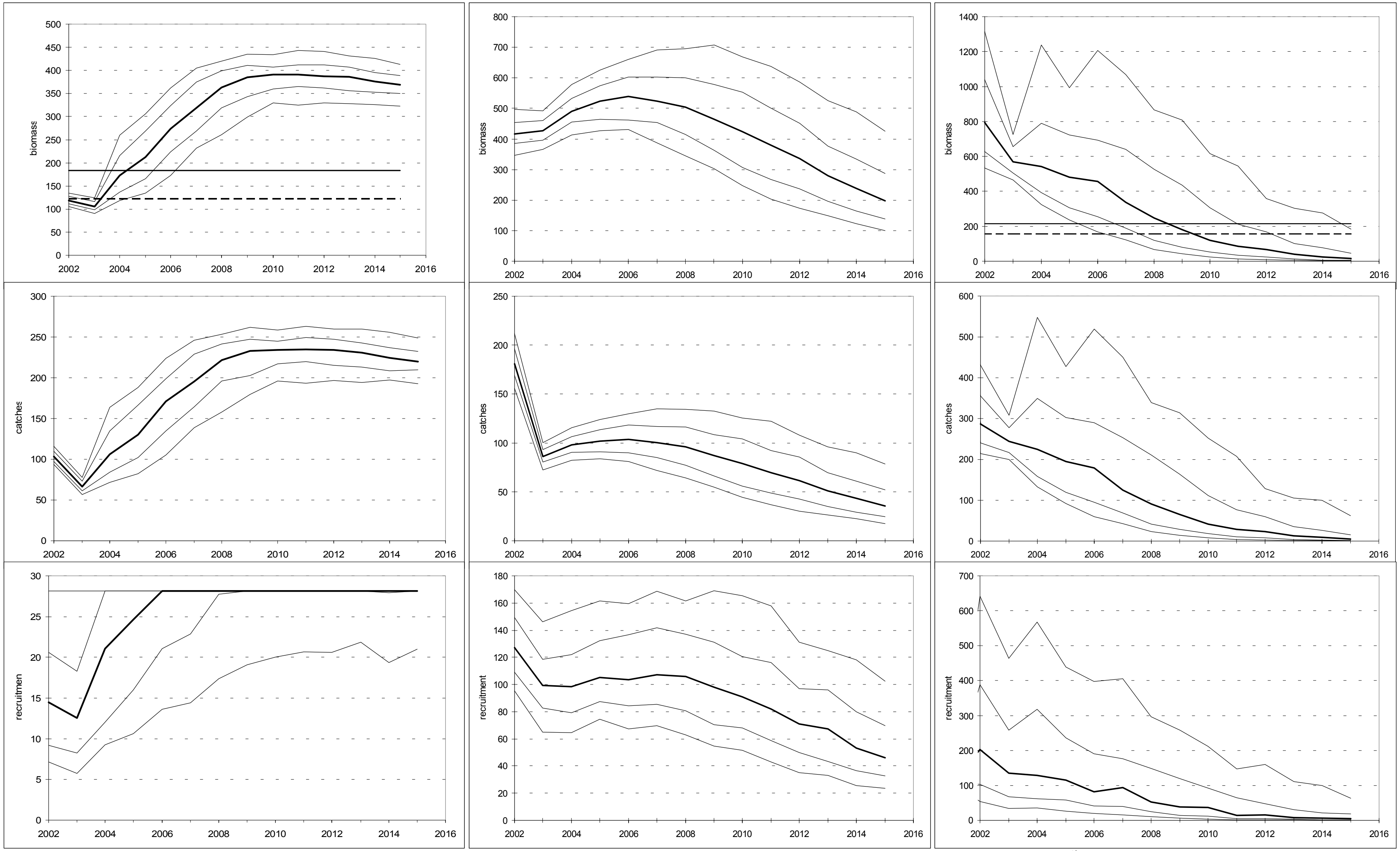


Fig. 6.3.33. Medium-term simulations using the multispecies production model. Lines show the 10, 25, 50, 75, and 90th percentile of the biomass, catch and recruitment distributions for cod (left panels), herring (mid panels) and sprat (right panels). Parallel lines indicate Blim and Bpa (values rescaled to the biomass estimates from the production model). Assumed low environmental conditions for sprat and high for cod. All species exploited at Fpa.

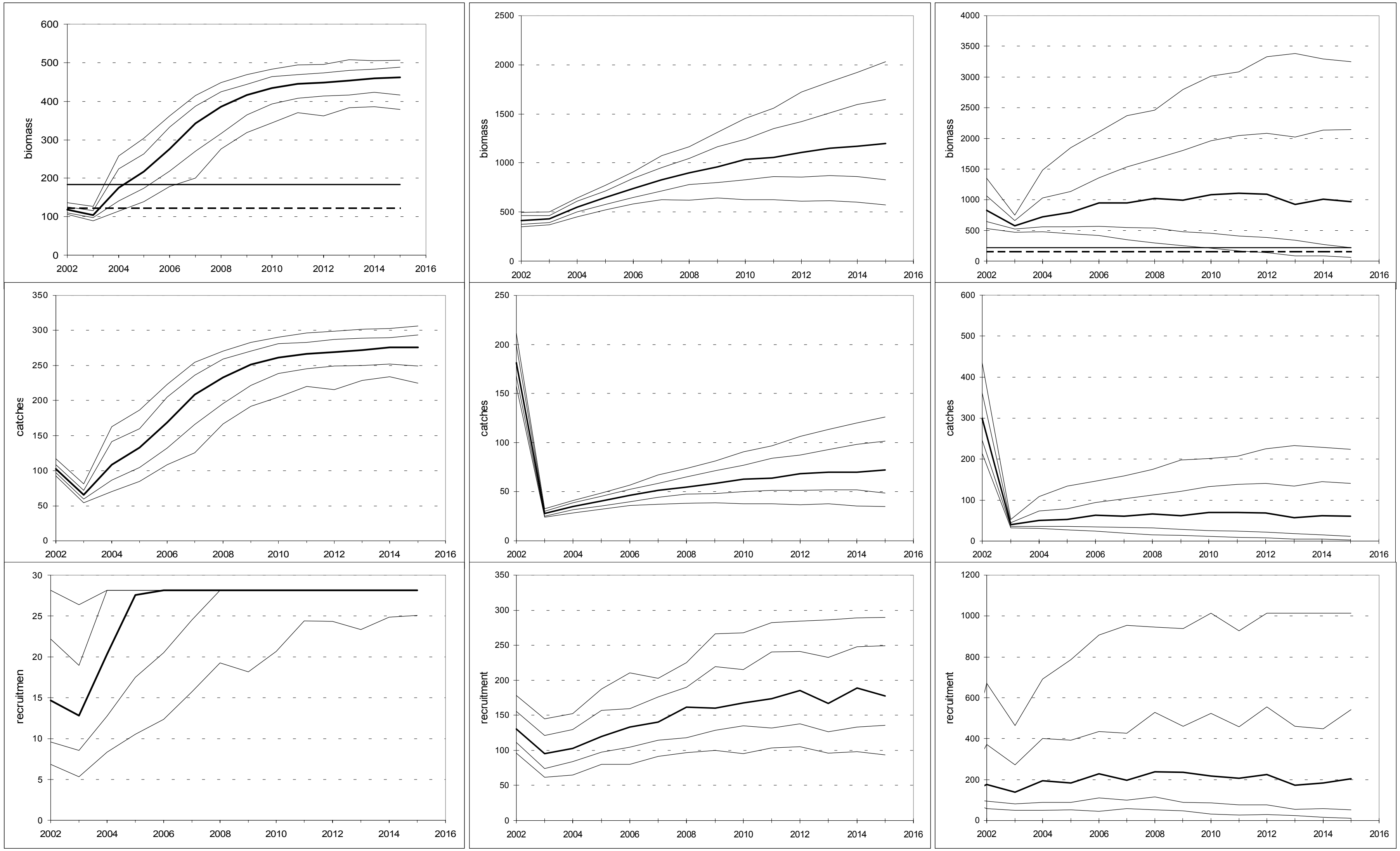


Fig. 6.3.34. Medium-term simulations using the multispecies production model. Lines show the 10, 25, 50, 75, and 90th percentile of the biomass, catch and recruitment distributions for cod (left panels), herring (mid panels) and sprat (right panels). Parallel lines indicate Blim and Bpa (values rescaled to the biomass estimates from the production model). Assumed low environmental conditions for sprat and high for cod. Cod exploited at Fpa, sprat and herring at F of 0.05

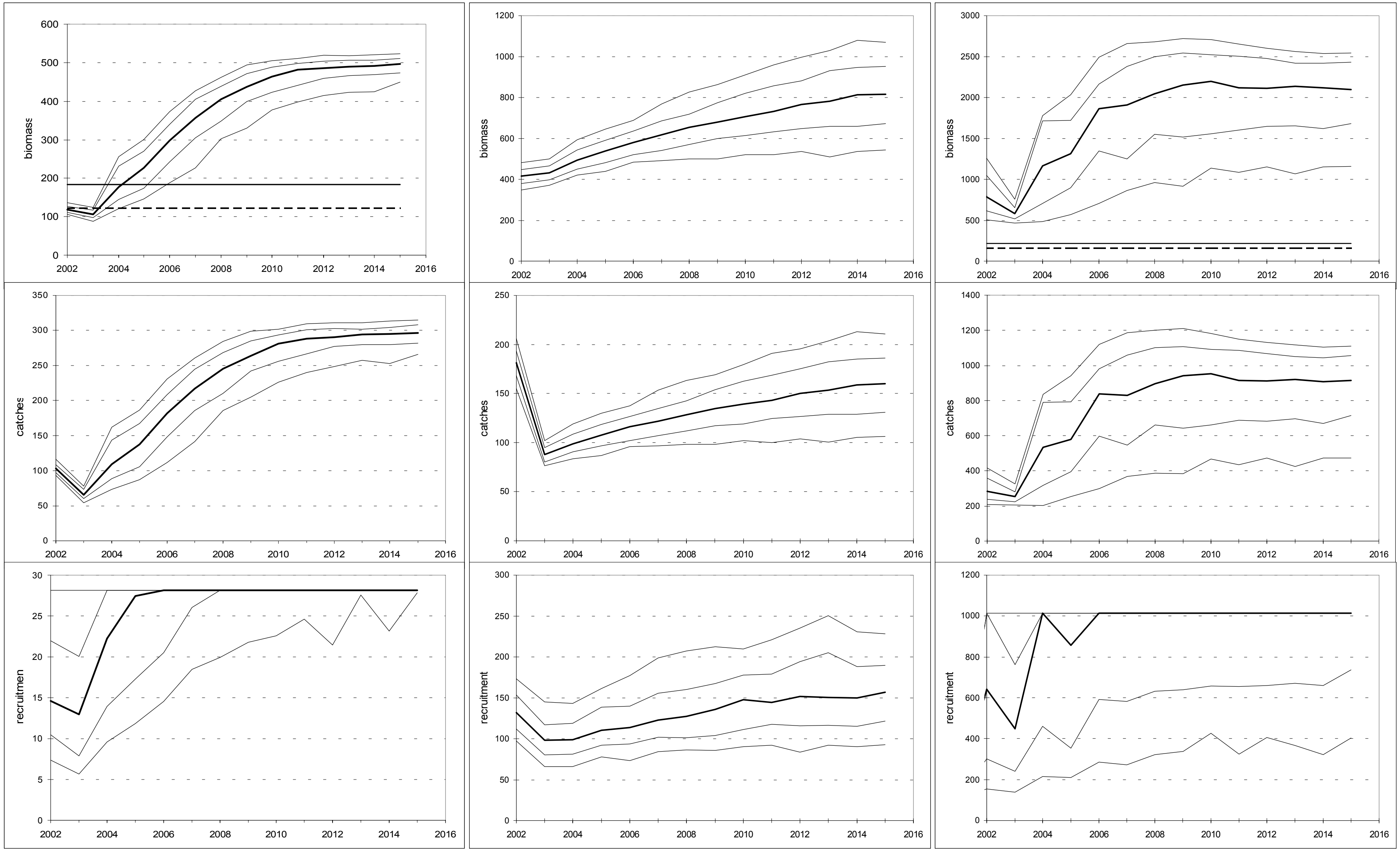


Fig. 6.3.35. Medium-term simulations using the multispecies production model. Lines show the 10, 25, 50, 75, and 90th percentile of the biomass, catch and recruitment distributions for cod (left panels), herring (mid panels) and sprat (right panels). Parallel lines indicate Blim and Bpa (values rescaled to the biomass estimates from the production model). Assumed high environmental conditions for both cod and sprat. All species exploited at Fpa.

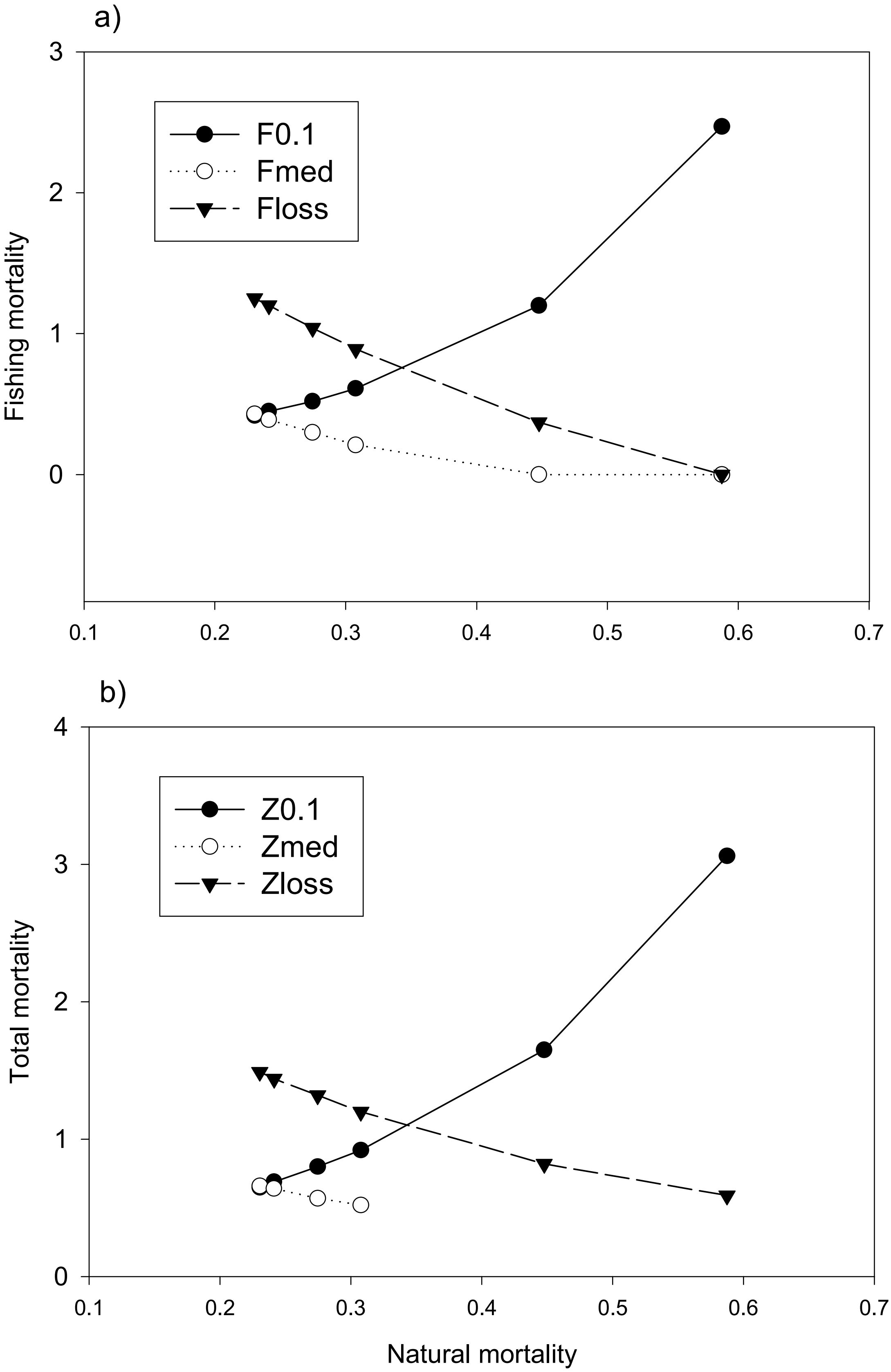
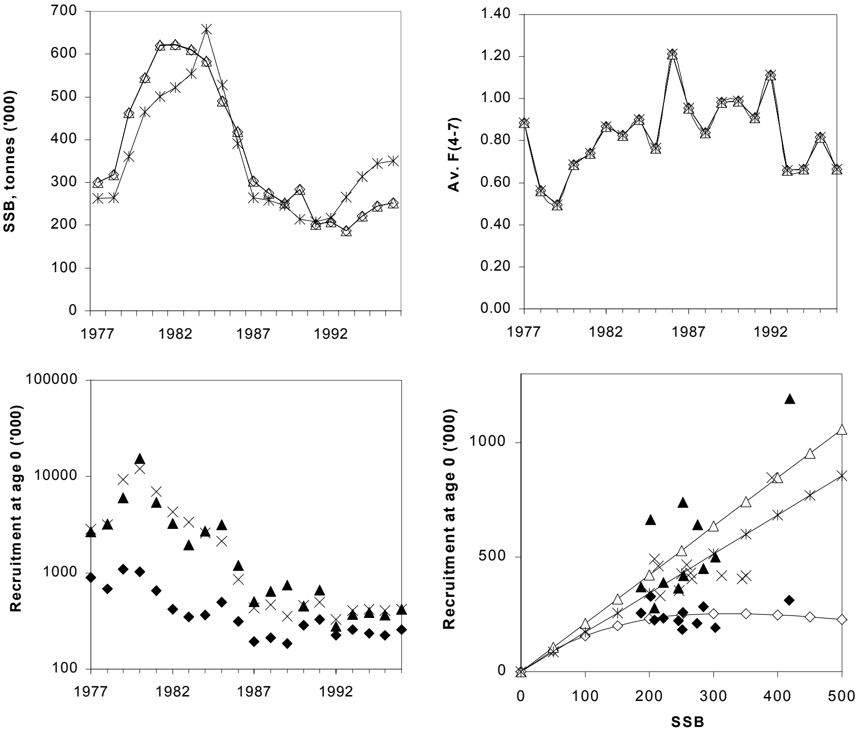
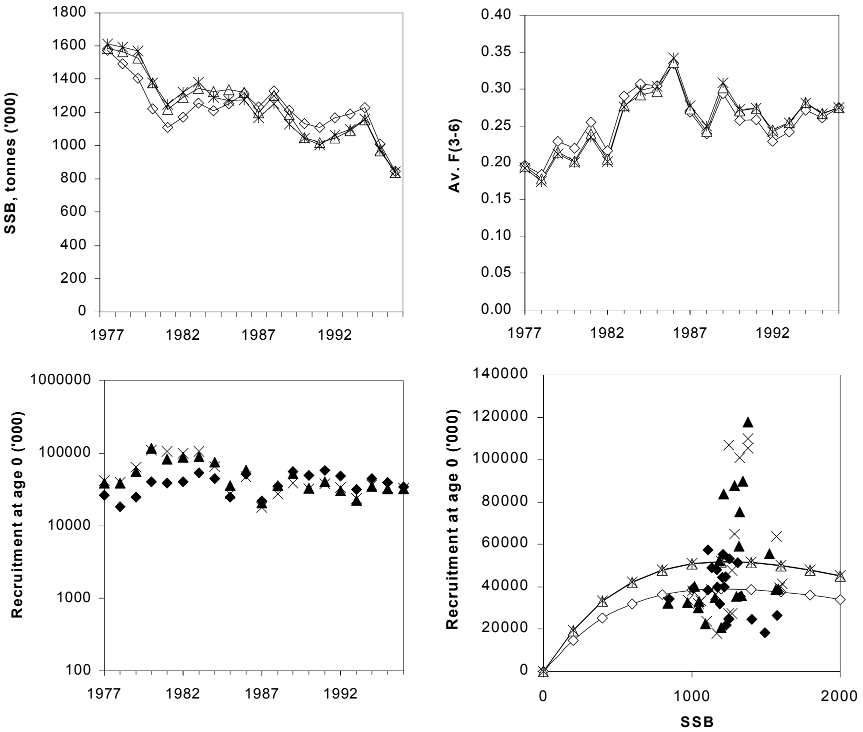


Fig. 6.4.1. Fishing (a) and total mortality referencepoints (b) of sprat at various levels of natural mortality

a)


SSB, tonnes ('000)
Av. F(4-7)
Recruitment at age 0 ('000)
Recruitment at age 0 ('000)
SSB

b)


SSB, tonnes ('000)
Av. F(3-6)
Recruitment at age 0 ('000)
Recruitment at age 0 ('000)
SSB

c)

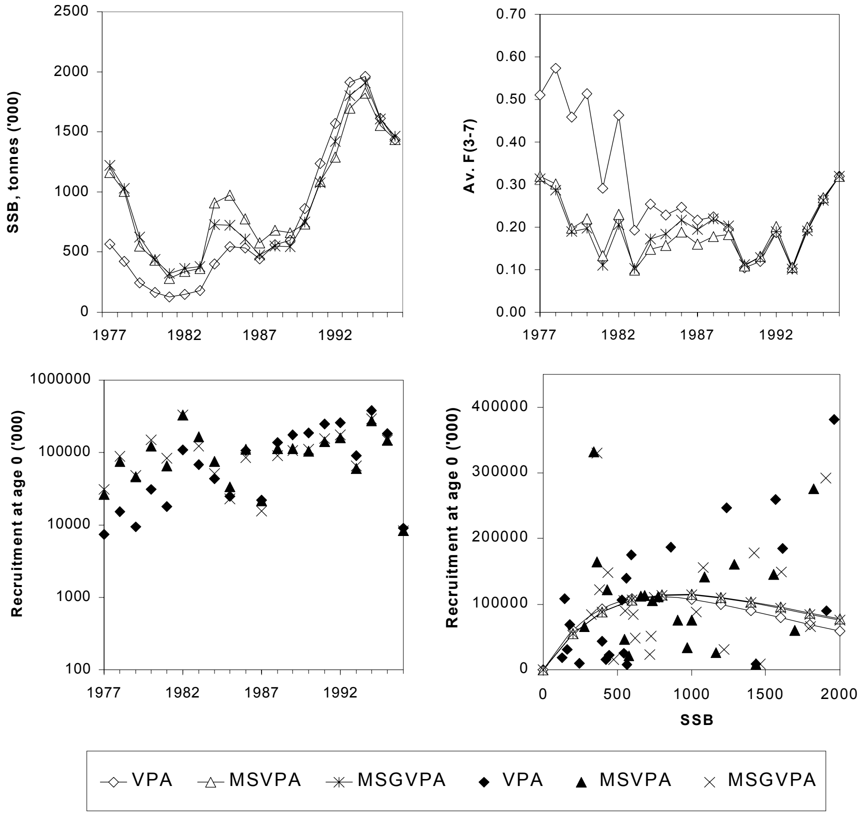


Fig. 6.4 2. Spawning Stock Biomass (SSB), average fishing mortality (F), recruitment, and SSB recruitment relationship estimated by single species VPA, MSVPA and MSGVPA. a) cod, b) herring, c) sprat.

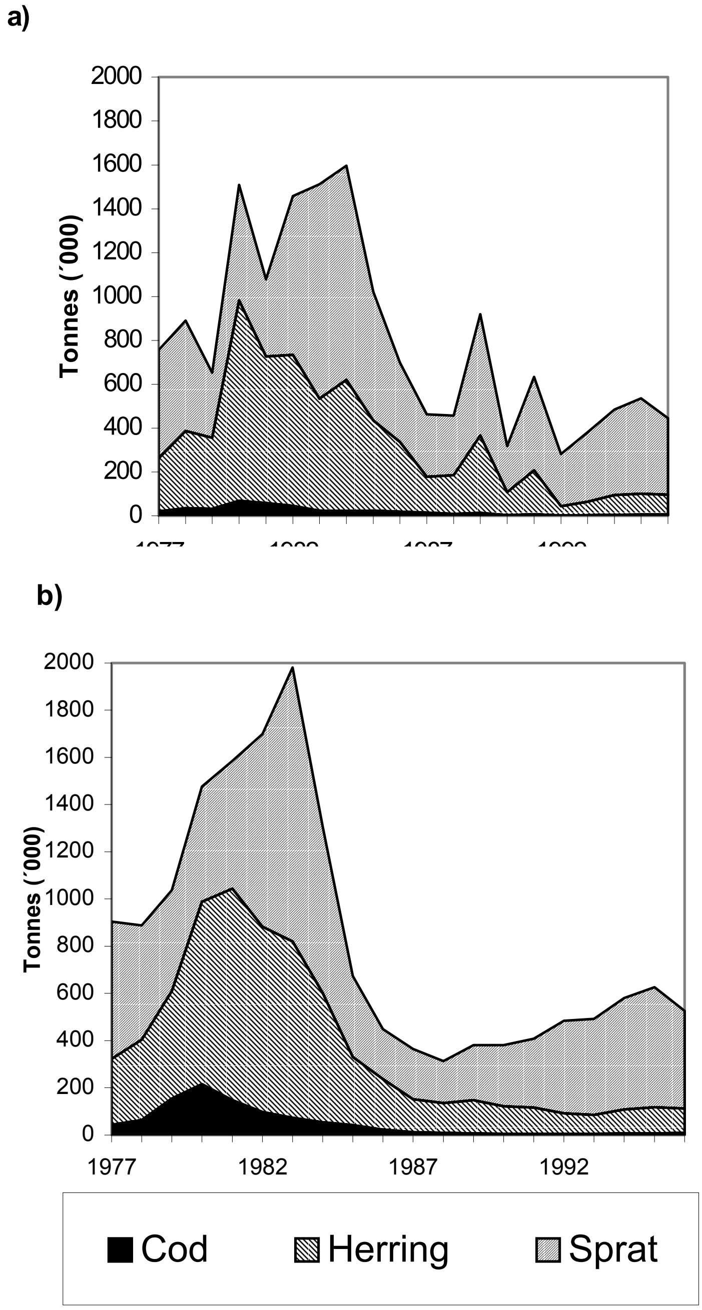


Fig. 6.4.3. Total consumption of cod, herring and sprat estimated by a) MSVPA and b) MSGVPA.

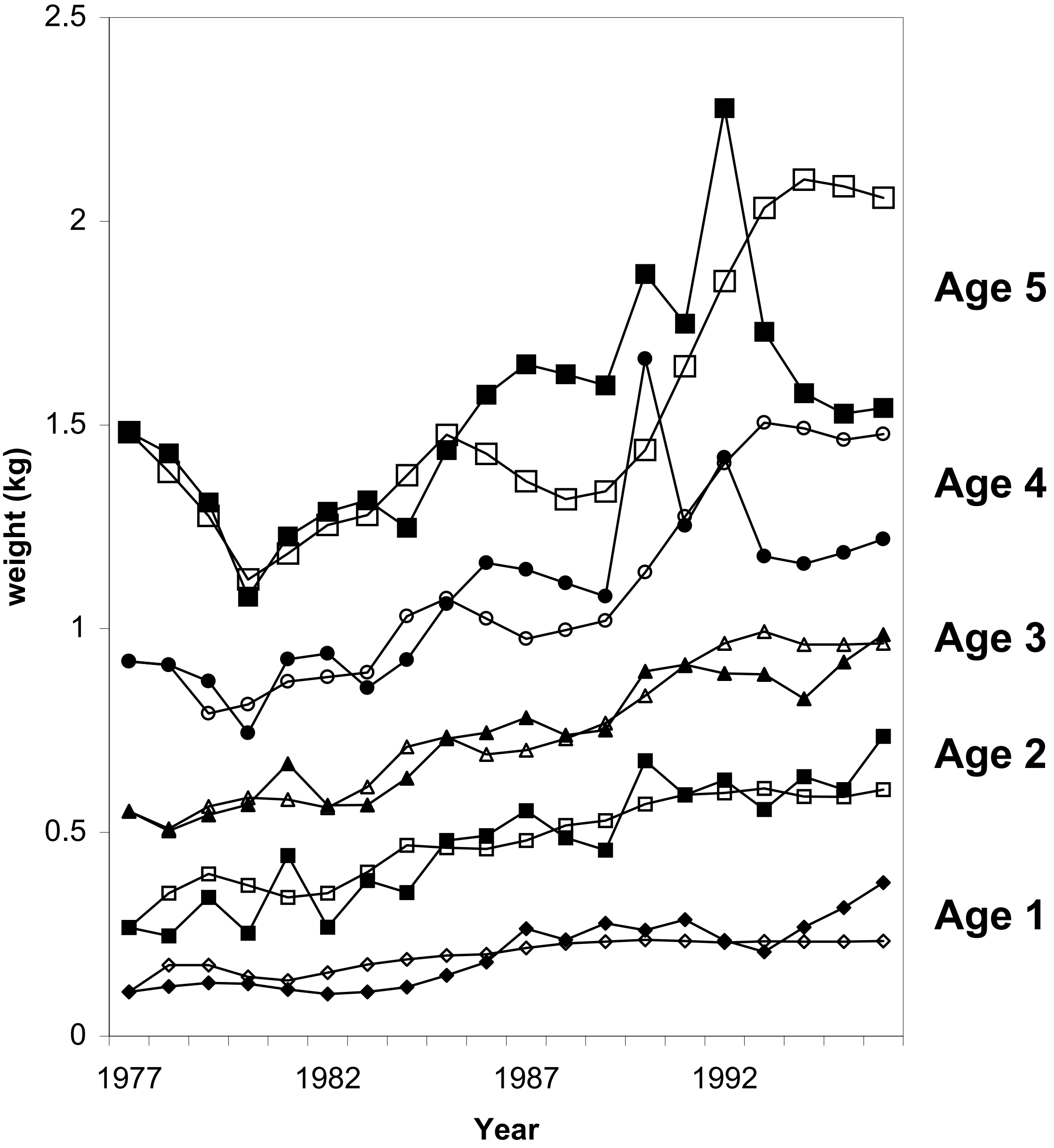


Fig. 6.4.4. Observed weight at age (filled symbols) of cod ages 1 to 5 compared to estimated weight at age from MSGVPA (open symbols).

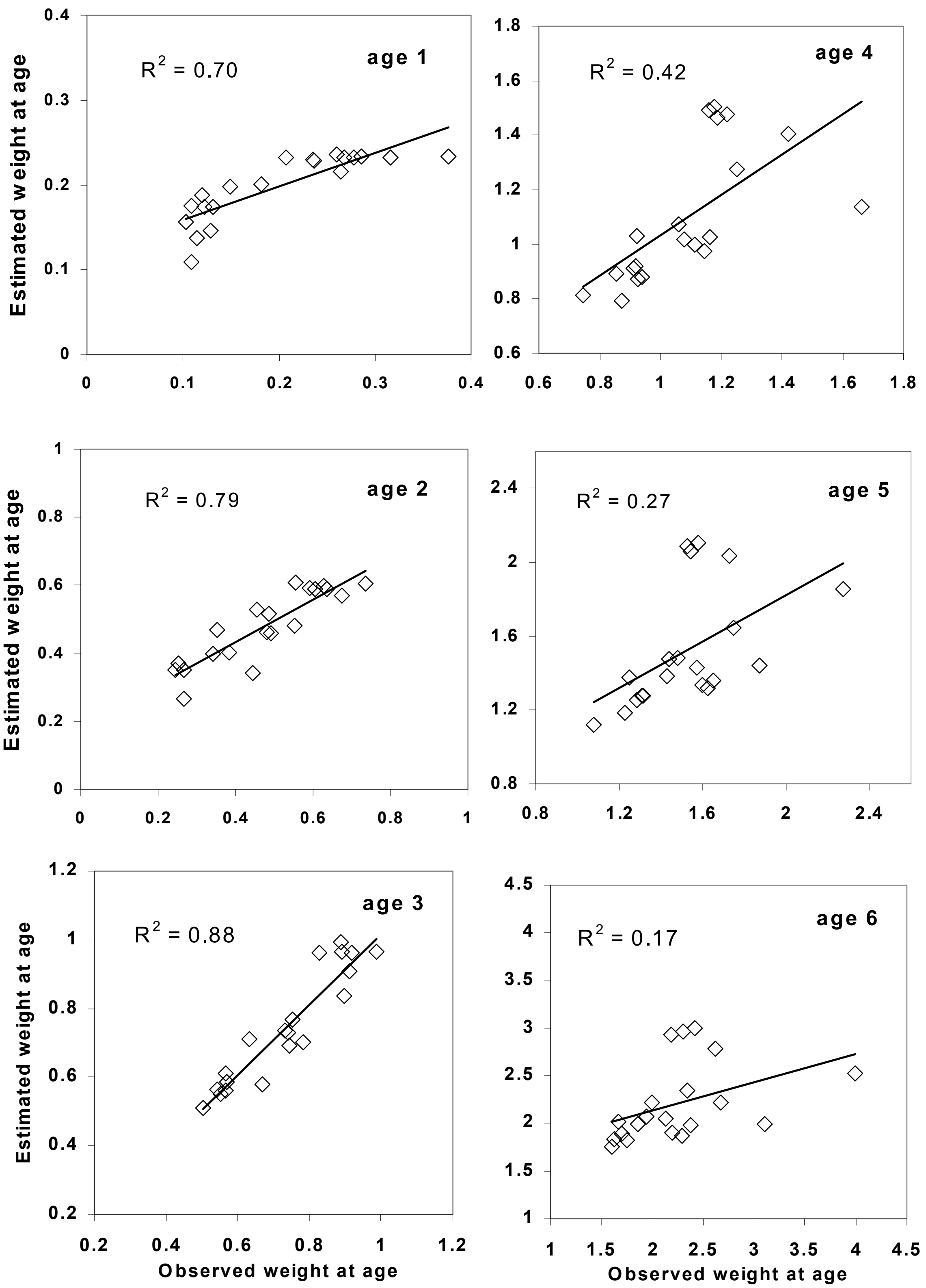


Fig. 6.4.5. Estimated versus observed weight at age for cod ages 1 to 6.

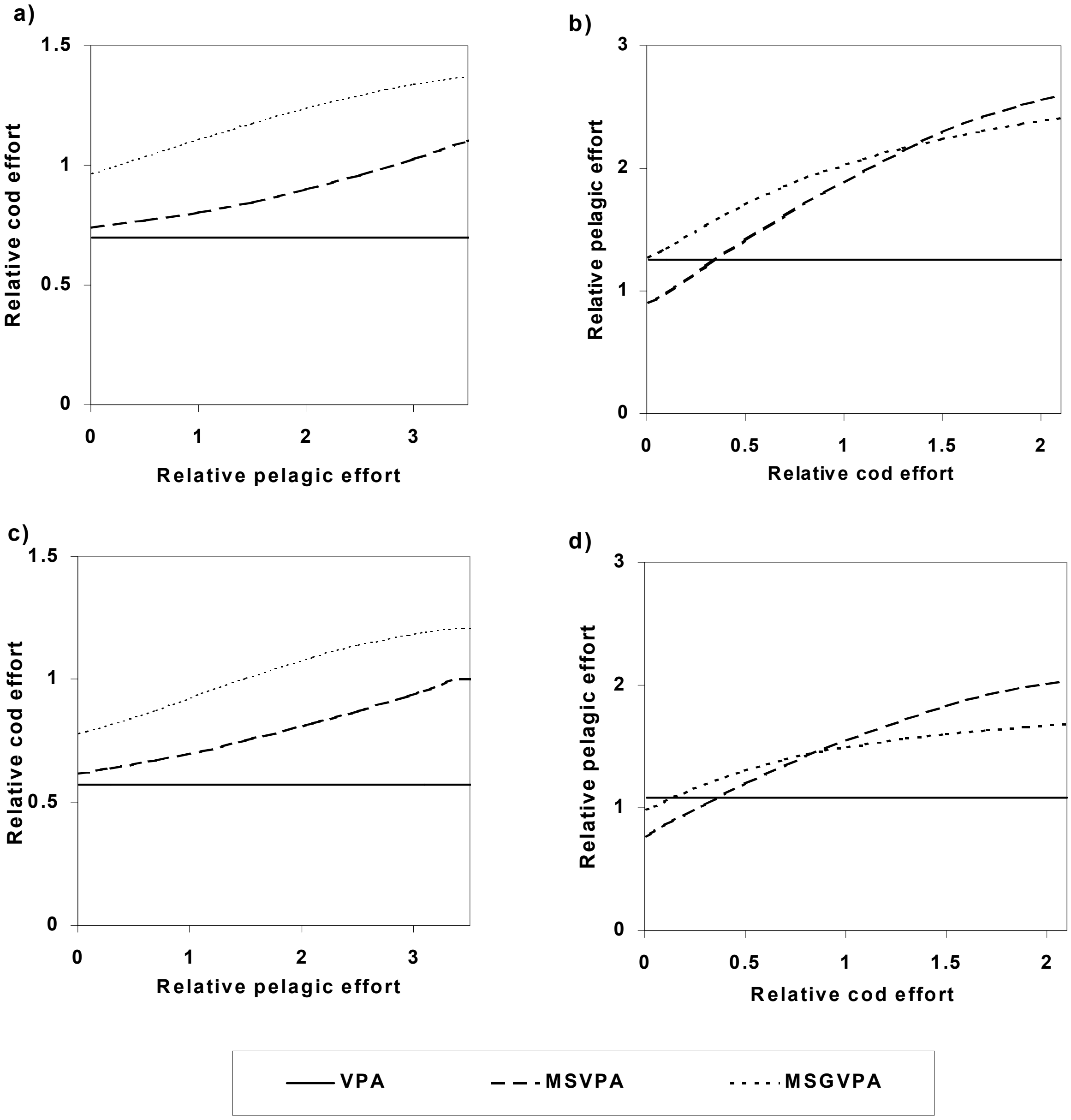


Fig. 6.4.6. Relative effort corresponding to F_{MSY} (a) or $F_{0.1}$ (c) in the cod fishery versus relative effort in the fishery for pelagic species, and relative effort corresponding to F_{MSY} (b) or $F_{0.1}$ (d) in the pelagic fishery versus relative effort in the cod fishery.

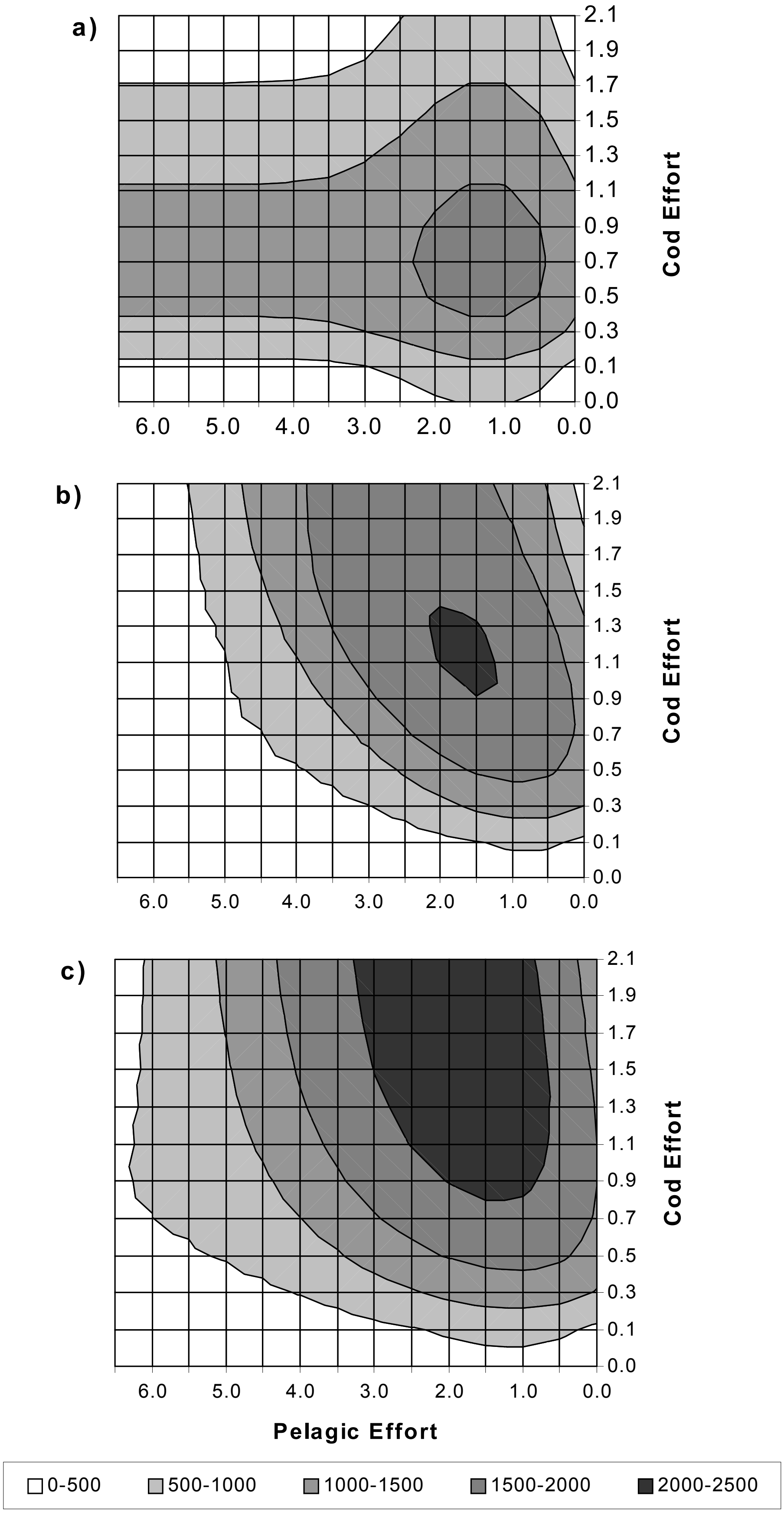


Fig. 6.4.7. Relative total value of catch for different combinations of effort in the pelagic and cod fishery. Cod assumed to be ten times as valuable as herring and sprat. a) Single species predictions, b) MSVPA, c) MSGVPA.

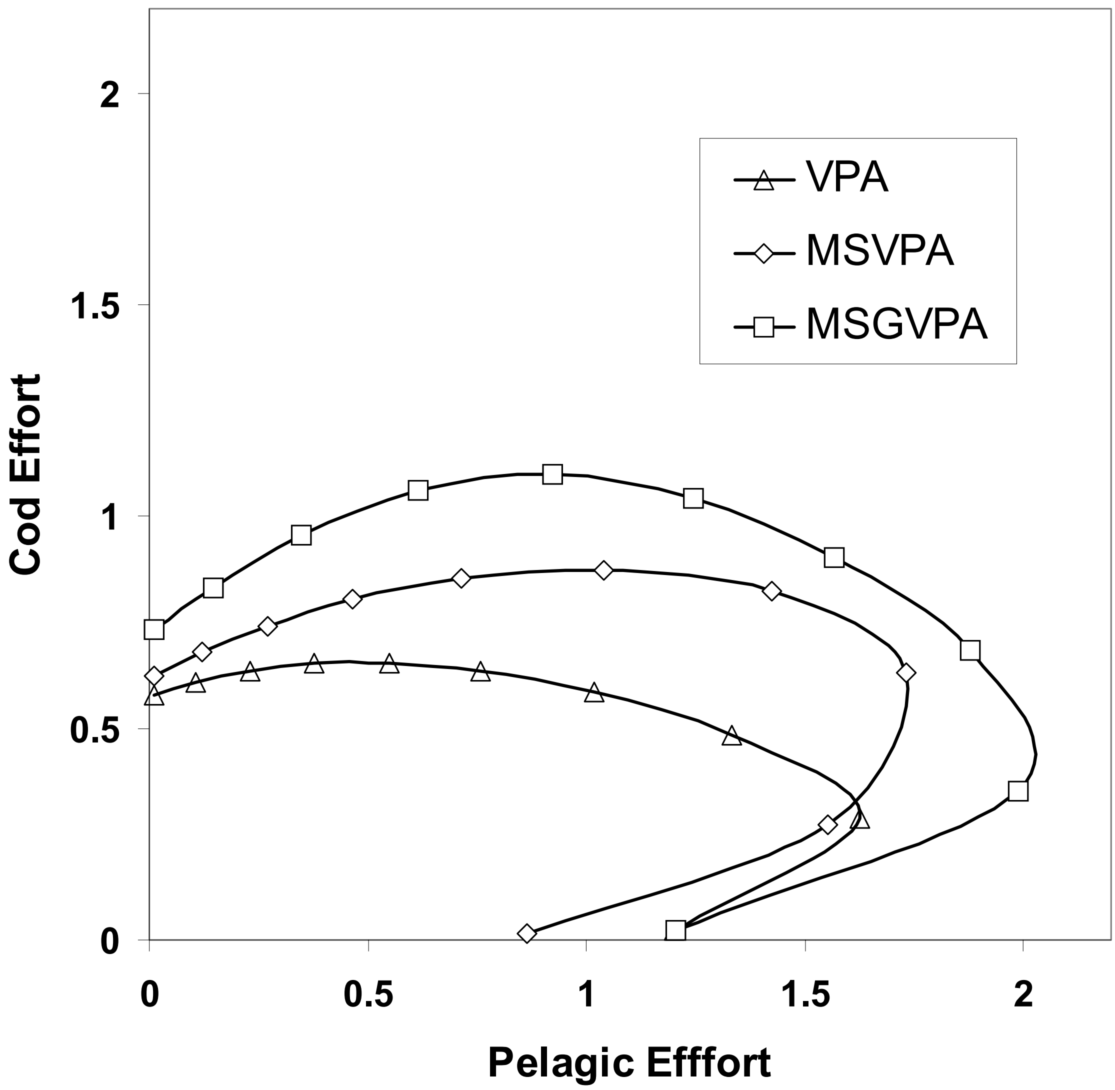


Fig. 6.4.8. Isolines of $F_{0.1}$ estimated by Single species predictions, MSVPA and MSGVPA. $F_{0.1}$ estimated as the effort combination where the slope of the relative value of the total catch is one tenth of the slope at the origin.

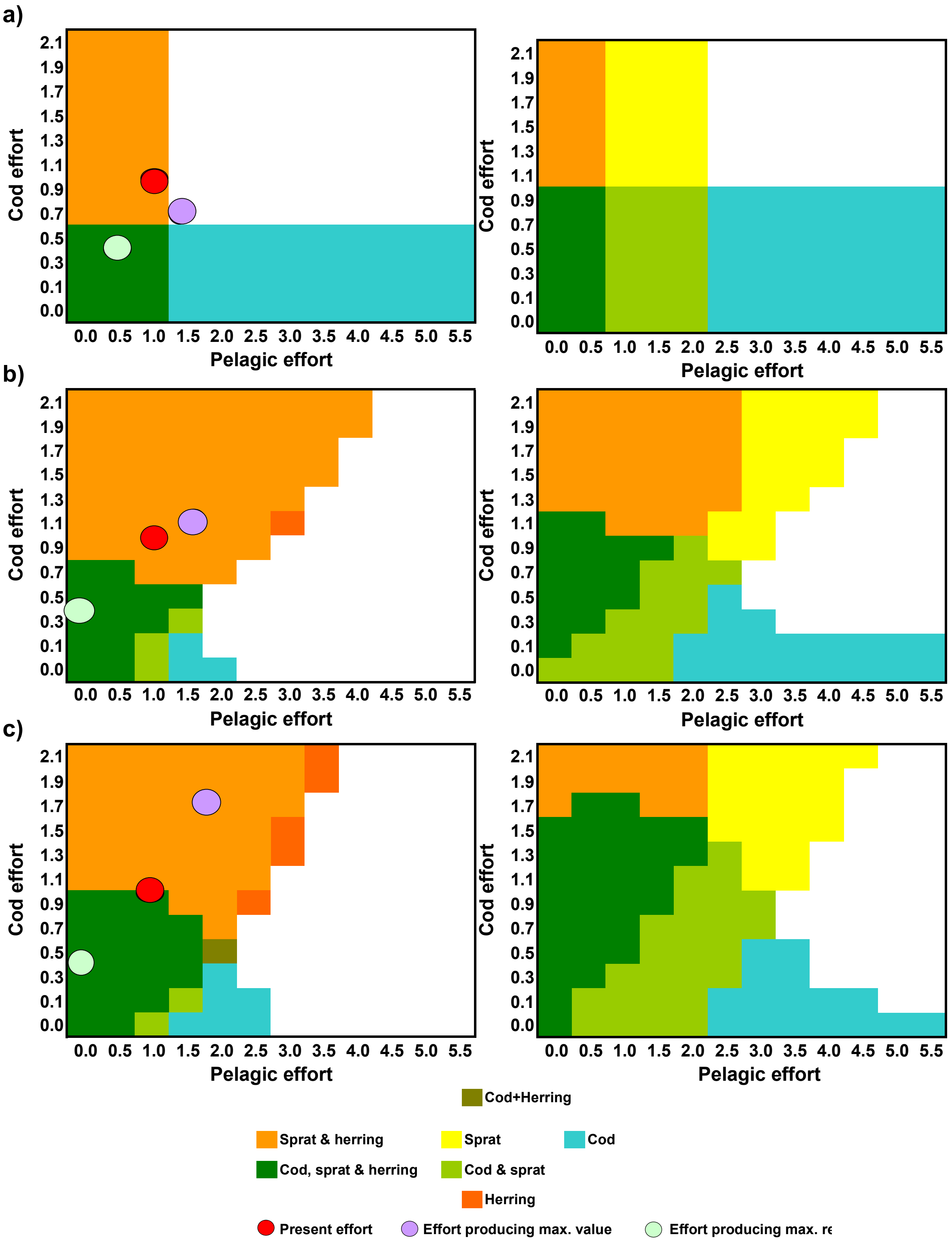


Fig. 6.4.9. Effort combinations for which the predicted SSB is above either 50% of the virgin SSB (a,b,c) or above Bpa (d,e,f) shown together with the effort combinations corresponding to the current fishing mortality, maximum overall value of catch and maximum net revenue. Bpa equal to 240, 1000 and 275 thousand tons for cod, herring and sprat, respectively (ICES 1998). a,d) Single species predictions, b,e) MSVPA, c,f) MSGVPA.